 25X1

[redacted]

DATE 23 December 1965

TO [redacted] FROM [redacted] 25X1

SUBJECT 4x5 Chip Processor Evaluation Program

COPIES [redacted]

In response to several questions posed by our customer concerning subject program, will you please advise him in your official capacity as company representative as follows.

Reference: Our Proposal Evaluation Program for the 4x5 Chip Processor, dated 11 November 1965. Three (3) copies attached.

Under Phase II, Items 2 and 3, page 3, we do intend to utilize resolution targets and gray scale exposures as well as the step wedges mentioned in Item 2.

Further, we plan to use only the manufacturers recommended standard chemistry solutions for the various emulsions to be tested. In the event that satisfactory results are not obtainable with these standard solutions, we would then run a minimum amount of special chemistry runs to determine the direction in which the chemistry must be changed in order to obtain satisfactory results (Ref. Ph II, Item 4).

A check will be made to determine the adequacy of the replenishment system in maintaining the desired ph level required to obtain the theoretical results as dictated by the fixed speed, time in bath, and temperature of the machine.

In reference to Evaluation of Processed Material, page 4, Item No. 3, the "Freedom from physical damage" inspection will include a microscopic examination of the processed chips to determine not only the presence of physical damage, but also to determine if possible, the presence of any observed damage.

In respect to Gamma, page 5, item 5, we will plot the resultant H & D curves as stated. However, since this machine incorporates a fixed transport speed and operating temperature, we will make exposures over a given range and then make a comparison of the curves obtained to standard curves to determine if the processor is capable of producing the gamma required for the intended use of the film chips.

If the customer should have any other questions, or desire any further amplification, please advise.

25X1

[redacted]

MCM:ml

R & D CATALOG FORM

DATE:

1. PROJECT TITLE/CODE NAME
Photographic Techniques and Equipment Evaluation Program

2. SHORT PROJECT DESCRIPTION
A program to investigate methods and techniques in the printing-processing field and to test and evaluate various types of developmental equipment.

[redacted]

25X1

5. CLASS OF CONTRACTOR
Manufacturer

6. TYPE OF CONTRACT
Open End

7. FUNDS

FY 19 65	[redacted]
FY 19 66	[redacted]
FY 19 67	[redacted]

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8. REQUISITION NO.

9. BUDGET PROJECT NO.
NP-RT-9

10. EFFECTIVE CONTRACT DATE *(Begin - end)*
February 1966 - Continuing

11. SECURITY CLASS.
AA-Secret
T-Unclassified
W-Unclassified

12. RESPONSIBLE DIRECTORATE/OFFICE/PROJECT OFFICER TELEPHONE EXTENSION
DDI/NPIC/P&DS, [redacted]

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13. REQUIREMENT/AUTHORITY
All effort directed toward photographic exploitation as performed by the NPIC is dependent upon the reproduction techniques, materials and equipments to produce the required materials. Advanced technology is necessary in this area to maintain pace with the rapidly advancing acquisition materials. While the original (Cont'd)

14. TYPE OF WORK TO BE DONE
Applied Research and Engineering Development

15. CATEGORIES OF EFFORT

MAJOR CATEGORY	SUB-CATEGORIES
Reproduction Techniques and Materials	Chemistry
	Film Processing-Printing

16. END ITEM OR SERVICES FROM THIS CONTRACT/IMPROVEMENT OVER CURRENT SYSTEM, EQUIPMENT, ETC.
This contract will provide for investigation into methods and techniques for the improvement of exploitation materials. Additionally, it will provide direct support in testing and evaluating various types of developmental equipment.

17. SUPPORTING OR RELATE[redacted]TION
Coordination with [redacted], RADC, SAC and PSD/NPIC has been effected. This R&D Catalog Form effects coordination with the Agency

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18. DESCRIPTION OF INTELLIGENCE REQUIREMENT AND DETAILED TECHNICAL DESCRIPTION OF PROJECT *(Continue on additional page if required)*
This Agency has funded the construction of a complete ~~cleanroom~~ controlled environment complex and research laboratory in the [redacted] This installation has met the cleanliness specifications and has been accepted from the subcontractor. It is not, however, being used to the extent originally intended. By initiating a well managed program to investigate photographic techniques and furnish a well equipped support test facility, this installation will become a much needed evaluation tool for all types of photographic reproduction and interpre-(Cont'd)

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19. APPROVED BY AND DATE

OFFICE	DEPUTY DIRECTOR	DDCI

FORM 11-64 23

13. Continued...

processing and mass reproduction is the responsibility [redacted] many in-house requirements exist for special capabilities and techniques which are of little or no direct interest to that organization. 25X1

18. Continued...

tation techniques and equipment. This important phase of all NPIC research and development is an extremely neglected area, due to the lack of proper in-house facilities and staffing.

The investigative areas concerning photographic techniques and materials will be established by levying specific tasks in support of direct (current) and indirect (long range) in-house requirements upon the contractor. Certain promising areas of endeavor initiated under Contract [redacted] in support of PSD's requirements will be followed to a logical conclusion during the first part of the program, these being: 25X1

(1) Heat Shock as applied to acceleration of development time. Research thus far has produced positive results in accelerated development time without xxxx loss of resolution or grain growth. Continued effort in this area will be to investigate the application in conjunction with special chemistry to speed up different black and white and color processes.

(2) Film Drying Techniques as applied to photo reproduction. Under Contract [redacted] advanced methods of film drying have been investigated including vacuum and radiant heating, vacuum and low temperature, and solvents in conjunction with ultrasonic action. Preliminary analysis has shown promising results by use of the solvent-ultrasonic techniques. Further analysis, testing and evaluation will be performed under this task with resultant design parameters established for a prototype high 25X1

efficiency, high speed film drier.

Additional tasks will be established as the requirements are clarified and coordinated with the appropriate division. Some limited effort has been applied in the following areas but further investigation is required to reach any meaningful conclusions:

(1) Color Materials Evaluation - pertaining to other than EK products.

(2) Non-silver, silver dry and semi-dry processes for rapid access viewer-printer requirements.

(3) Exposure compensation through dye developer inhibitors - a processing chemistry investigation to stop or slow down development action in over exposed areas.

(4) Use of ultrasonics to accelerate development - It has been established that many chemical reactions are accelerated by the addition of ultransonic energy to the reaction bath. This should be directly applicable to the photographic process. Testing should be run to appraise the effect of ultrasonic energy on development rates, image quality, granularity, etc. and similar effects in the case of short stop, fixation and washing. There is a distinct possibility that this effort will introduce a new method of solution agitation particularly applicable to compact processors.

Under the equipment evaluation portion of this contract will be included several equipments now built or in fabrication. This equipment in order to be useful and productive tools in an operational complex, requires that complete test and evaluation of performance criteria be established prior to being placed in a production complex. The contracts under which most of the equipments are being built contain little or no such test parameters - which is normal procedure under prototype R&D equipment contracts, as it is often impossible to

xxk

set up specific acceptance criteria on "first-time" items. The research laboratories and the associated environmental ~~clean room~~ facility (which is to be fully equipped with all necessary services) is an excellent location to perform this type evaluation, since controlled environmental conditions (temperature, humidity) can be imposed to any desired degree. The clean area itself is so constructed to handle nearly any size equipment in two larger rooms and contains two additional small laboratory areas for sensitometric work or small equipment testing - a total of 1200 square feet. This research complex need not be restricted to testing of any special type equipment simply because it was designed for reproduction and processing development. Viewing equipment, mensuration equipment, optical equipment and the like may be tested and evaluated. Some of the equipment under consideration for including in the ~~this~~ evaluation aspects of the program are:

(1) The 4"x5" film chip processor.

(2) The Sepratron Film Processor. The prototype now being fabricated is for roll film. It is believed, however, that the principle has great prospects for handling cut film and paper stock.

(3) The chip printer in conjunction with the chip processor.

(4) The dry process step and repeat printer (3-M).

(5) The Xerox step and repeat printer.

By performing external testing and evaluation of equipment, PSD and other NPIC components will be relieved of the responsibility of attempting to evaluate R&D prototypes when they have a production schedule to maintain and will insure that only fully operational equipment is placed on the production line. It is anticipated that where practical the original manufacturer will contribute to the testing so that full utilization can be made of his experience and knowledge of the subject.

~~The Photographic Techniques and Evaluation Program will be jointly managed by NPIC,~~ [redacted] ~~and SPPL. Funding and monitoring of individual tasks will be by the organization levying the task.~~ Contractual negotations will be through normal NPIC channels as an "open-end" type contract so that tasks can be added or deleted as the need arises. Initial funding is ~~by SAFSS and SPPL~~ in the amount [redacted]. ~~The FY-66 NPIC contribution o~~ [redacted] ~~will be added after funding approval.~~ Management control will be enforced ~~by a CCB team representing each of the three organizations concerned and~~ through bi-monthly meetings with the contractor and contracting officer present. ~~will be held~~. The contractor will submit bi-monthly reports to be on hand sufficiently in advance of the scheduled meetings so that decisions may be firm prior to the meetings. 25X1

6 January 1966

PHOTOGRAPHIC TECHNIQUES AND EQUIPMENT EVALUATION PROGRAM

I. This program would be conducted by [redacted] 25X1 25X1 The Agency has a complete clean room facility which is installed at the [redacted] 25X1 At the present time this facility is not being utilized to the extent that it was intended. By expanding the present film processor evaluation program into a photographic techniques and equipment evaluation program, this clean room facility could become a productive and worthwhile tool in evaluating all types of photographic reproduction and interpretation equipment and techniques which we can not evaluate in the Center due to lack of facility and staff. There is indication that this program will be confunded by NRO and other parts of the intelligence community.

II. Present studies to be included in this program:

A. Heat shock in the use of acceleration of image development - Under the present study, [redacted] using heat shock, has 25X1 successfully produced stable images in which the density has been raised from 3 stops under normal exposure to normal without appreciable grain growth or loss of resolution. A continuation of this study under the new program would include work in controlling heat shock application and to investigate the use of heat shock in conjunction with special chemistry to speed up different B&W and color film processes.

B. Film drying techniques - The results of this program will be used in the design of a prototype high efficiency, high speed film dryer. Under the present program different advanced methods of drying, including vacuum and radiant heating, vacuum and low temperature drying, the use of solvents, and the use of solvents in conjunction with ultrasonic action, have been experimented with. A continuation in this study task should result in the design and fabrication of a sophisticated film dryer.

C. Sensitometric Processing - There is a need for a small compact research processing machine capable of operating over a wide range of both time and temperature and capable of reproducing the many methods of agitation normally used. This processor is a necessary tool in accurately comparing particular emulsion characteristics against standard characteristics published by the manufacturer. Under the present study time and temperature combinations have been experimented with. With current available apparatus the highest temperature and lowest time combination, found to produce accurate results, was 118°F and 15 seconds.

III. Processing and printing equipment evaluation as new prototype printing and processing equipment is completed, it is desirable to evaluate this equipment to determine if this equipment meets all specifications, if this equipment will do the job it is intended to do, the limits of what this equipment will do and how well this equipment was built. The clean room facility (which is fully equipped with all necessary services) is an excellent location to perform these evaluations. At the present time there are several pieces of prototype equpment being built that could be part of this evaluation program.

A. 4x5 Film Chip Processor - Houston Fearless

B. 4x5 Film Chip Printer - Fairchild

C. Sepatron Processor - Houston Fearless

D. High Resolution Step & Repeat Printer - Xerox

IV. Other fields of desired research -

A. Color materials evaluation - Under contract [redacted] 25X1

Eastman Kodak has performed an extensive evaluation in color materials for exploitation use. These materials were limited to E.K. products only. It is necessary to evaluate all manufacturers color materials for their application in exploitation use with specific applications as follows:

1. Contact transparencies
2. Enlargment transparencies
3. Briefing prints
4. Color negative materials

B. Investigation in depth of all non-silver and silver dry and semi-dry processes. There is an immediate requirement for a rapid access viewer printer to produce a positive paper print, from a positive transparency,having the quality close to kopabromide. Before the equipment can be built the appropriate printing material has to be established. The first step in establishing the appropriate material, is to investigate in depth the characteristics of all commercial and research products that might fill this requirement. As speed and overall equipment size is critical, this investigation should be limited to only dry and perhaps semi-dry processes.

C. Exposure compensation through dye absorbtion developer inhibitors - A unique method of exposure compensation is proposed, based on the inclusion in the developer of a dye-coupler molecule which will couple with the reaction products of development (e.g. bromide ion) to inhibit fruther development. The dye (white, or light colored) formed would deposit on the developing action occurring; that is to say, where the greatest developing action is taking place, in the overexposed areas, the deposit would be heaviest with the reverse effect in underexposed areas.

The effect can be utilized in two ways, first the deposition of the dye on the overexposed areas will prohibit further development while permitting the development of underexposed areas ~~af~~ to continue. Secondly, by the use of radiant (infrared) heat further control of development can be obtained since the infrared will be reflected from the heavily coated areas and absorbed by the uncoated areas.

A further extension of the foregoing program would be research into the formulation of a developer that would have the property of negative Kinetic potential. This would be effected by the inclusion of a coupler molecule, which, in place of the formation of a dye coating, would couple with the reaction products of development to decrease the electro-chemical energy of the developer, thereyb retarding development in overexposed areas. Conversely, development in underexposed areas, would be accelerated since a cessation or decrease in development inhibition would be effected due to the corresponding decrease in reaction products.

D. Developer luminescence - This phenomenon has never been thoroughly investigated with regard to photographic materials and processing. Research into this area might well result in advances in the state-of-the-art. Some logical reasons for investigation into developer luminescence are:

1. A basis for real-time chemical analysis of developers.

2. Automatic control of replensihment if the luminescence is proportional to the chemical activity of the developing agents.

3. If the luminescence wavelength and intensity do increase exposure levels of silver halides, then controlled amounts of luminescence could be used to produce intensification of the latent image.

4. If on measurement ,the luminescence does not increase or promote fogging of silver halide emulsions, then perhaps the light output could be used for visual monitoring of processing operations.

E. Use of ultrasonics to acceleate development - It has been well established that many chemical reactions, particularly those requiring diffusion for completion, are accelerated by the addition of ultransonic energy to the reaction bath. This should be especially applicable to the photographic process. A series of tests should be run appraising the effect of ultransonic energy on rate of development, image quality, granularity, etc. and similar effects in the case of short stop, fixation, and washing. There is the distinct possibility that all other standard forms of solution agitation might be eliminated, particularly important in some of the industry's latest compact processors. Some of the newest solid-state transducer power supplies are smaller physically than the fractional horsepower motor and pump units currently used in these processors.

F. De-gassing and de-oxidation - The primary factor in developer exhaustion other than direct usage is inherent in aerial oxidization. The oxidization products, besides drasitcally reducing developer life, may have an adverse effect upon yhe developing action. If anti-oxidants could be reduced or eliminated improvements in the photographic process would result, in addition to opening the door to new active developing agents. This project would investigate various methods of de-gassing on emulsions, and the effect of the removal of anti-oxidants from developing solutions.

G. Non-reversable photobleaching liberation products. General Electric is researching.

A. Positive to positive non reversal type photobleach process.

XX In this process many chemical molecules are liberated into the surrounding atmosphere. The clean room facility is excellent to determine what these liberated products are, what amounts are present and if these products have any adverse effects on individuals using the process or on other photo sensative materials that might be close by.

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PROPOSAL FOR AN ANALYTICAL STUDY TO DETERMINE THE EFFECT OF CONTAMINATION ON PHOTOGRAPHIC IMAGE QUALITY AND INTERPRETATION

September 1965

25X1

Sanitized Copy Approved for Release 2011/06/09 : CIA-RDP78B04747A001300020002-4

ANALYTICAL STUDY TO DETERMINE THE EFFECT OF CONTAMINATION ON IMAGE QUALITY AND PHOTOGRAPHIC INTERPRETATION

1. The processing of original negative film necessitates extreme care in the mechanical handling of the silver halide emulsion, and also the elimination of contaminate (foreign) particles from the processing environment, if maximum image quality is to be achieved. The prime purpose of photography is interpretation of the image, if development is performed in a contaminated atmosphere, inevitably a degraded negative results. In this program, it is planned to develop a computerized mathematical model which will predict the quality of the image in quantized form, given certain factors describing the image, the film, and the contaminants.

2. At the present time little or no data are available to procurement agencies and to designers of armed services photographic laboratories on which to base a "cleanliness" requirement. One result of this mathematical model is the evaluation of the differences between "black, gray, white" and various degrees of "clean" photographic processing rooms as judged by the quality and interpretability of the image produced in them. Considerable dollar savings may be achieved, if step-downs in the degree of "cleanliness" of an environment result in none, or little image quality degradation or minimal image misinterpretation. Thus, this program will determine the degree of parametric minimal environmental cleanliness required for any specific degree of image quality.

3. The newly installed class 100 clean room complex at Houston Fearless is an essential tool for the conducting of this program. Control will be exercised over the contaminant parameters and observations made of the resultant image quality and readability.

4. The mathematical model will be developed as follows:

$$\hat{q} = \hat{A}a + \hat{B}b + \hat{E}e + \hat{F}f + \hat{G}g + \hat{H}h + \hat{S}s + \hat{T}t.$$

q = 0-----10 representing a subjective measure of image quality.

Each image will be judged by 10 service-trained photographic interpreters, on a scale from 0 (indicating utter confusion) through 10 (indicating perfect reading). To obtain a uniform

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standard of judgement among the interpreters, a short training period will be necessary on pilot negatives.

5. The following designates will be given:

$a = 0, 1, 2, 3$ representing none, slight, moderate and excessive aerosol contamination per unit area.

$b = 1$------10 representing background (type of terrain). A suitable coding system must be developed for this function, such that 1 represents the lightest, or whitest, background, for example, desert under sun, whereas 10 represents the darkest or blackest background, for example, forest under overcast.

$e = 0, 1, 2, 3$ to represent four commonly used emulsions.

$f = 0, 1, 2, 3$ representing none, slight, moderate and excessive fluid contaminate per unit area.

$g = 1, 2, 3$ representing minimum, normal and maximum average grain size.

$h = 0, 1, 2, 3, 4$ representing low to high camera height above terrain.

$s = 1, 2, 3$ representing small, moderate and large size of contaminate particles.

$t = 0, 1, 2$ will represent three different types, or shapes, of contaminate particle to be determined.

The capital letters are coefficients to be estimated by the least squares method. When estimated by computer these coefficients will form the "blue" or best linear unbiased estimate of $\hat{q}$ image quality q for given readings of the eight factors a, b, e, f, g, h, s and t.

6. Other numerical results forthcoming from the program will be the following:

1) The accuracy of the estimate, $\hat{q}$, of image quality, q, will be given in the form of 95 percent confidence limits of $\underset{=}{q}$ and $\bar{q}$ That is to say, "if a thousand experiments were performed on different populations and everyone of them produced exactly the same results, then, on an average 950 of the experimenters

would be correct in assuming that the curve q for a given set of factors is between $\underline{q}$ and $\bar{q}$. The outstanding 50 experimenters would be in error.

2) The "ANOVA," or analysis of variance, will provide information as to whether a significant difference in q does, or does not, exist due to changes in each factor a, b, etc. If it is discovered that any particle factor does not affect quality (for instance, it is conceivable that particle type, t, may have no effect), the model may be simplified by the omission of that factor and its coefficient in upper case (T).

3) It is anticipated that significant interactions between factors will be discovered. Thus, possibly for large values of h, small values of s may be degrading, whereas for small h, even a large size of s may not be degrading. If so, then in this example, the h-s interaction would be of significance.

7. Program BMD02R and BMD02V from BMD. Health Sciences Computing Facility, School of Medicine, UCLA, January 1964 will be used.

8. The study will be a complete replicate of a 4 x 10 x 4 x 4 x 3 x 5 x 3 x 3 (86,400) cell experiment with 10 observations (representing the 10 interpreters) in each cell. The within-cell variance with 9 x 86,400 (777,600) degrees of freedom is a highly satisfactory denominator for the classical F-test of significance.

9. The program as summarized in the chart on Fig. 1 and detailed in Fig. 2 is further clarified below. The item numbers also refer to the balloon numbering on Fig. 2.

Item 1. Classify contaminates according to

s = 0, 1, 2, 3 and t = 0, 1, 2.

Item 2. Classify contaminates into a = 0, 1, 2, 3 and f = 0, 1, 2, 3.

Item 3. Classify emulsion and grain size into e = 0, 1, 2, 3 and q = 1, 2, 3.

Item 4. Accurately define background and height into b = 1, --------10, and h = 0, 1, 2, 3, 4.

Item 5. Prepare pilot negatives.

Item 6. Confer with interpreters and develop uniform scoring system for q = 0-----10.

Item 7. Expose all negatives for complete program.

Item 8. Determine methodology for contamination of film samples.

Item 9. Process samples in contaminated environments.

Item 10. Process control samples in clean environment.

Item 11. Read and plot image quality of all samples.

Item 12. Devise suitable form to ease task of interpreters in judging negatives, recording q, and to facilitate card punching.

Item 13. Conduct training program of P.I. personnel.

Item 14. Present negatives in scheduled order to interpreters. This is a major task of the program.

Item 15. Write instructions to computer personnel at computer facility and transmit completed forms to them.

Item 16. Punching of computer cards.

Item 17. Computer processing and printout of results.

Item 18. Receive printout from computer facility.

Item 19. Evaluate computer printout.

Item 20. Write final report.

10. Program Breakdown.

The program as described in this proposal will be divided into 5 distinct phases, as follows:

PHASE 1.

a) Isolate, recognize and classify both aerosol and liquid contaminates into types, shapes, and sizes (Factors s & t).

b) Determine levels of both aerosol and liquid contaminates per unit area (Factors a & f).

c) In conjunction with project co-ordinator determine emulsions to be used, and group selective grain sizes (Factors e & g).

d) In conjunction with project co-ordinator determine terrains (backgrounds) and effective camera heights (Factors b & h) and determine source for master negatives of these.

e) Determine source and availability of photo interpreters.

f) Prepare pilot negatives.

g) Confer with interpreters and develop uniform scoring system.

PHASE 2.

h) Expose all negatives for complete program.

PHASE 3.

j) Determine methodology for contamination of film samples.

k) Process samples in contaminated environments.

l) Process control samples in clean environments.

m) Read and plot image quality of all samples.

PHASE 4.

n) Devise recording form to enter value judgements of q and to expedite card punching.

o) Conduct training program of P.I. personnel.

p) Conduct subjective evaluation of image samples by Photo Interpreters.

PHASE 5.

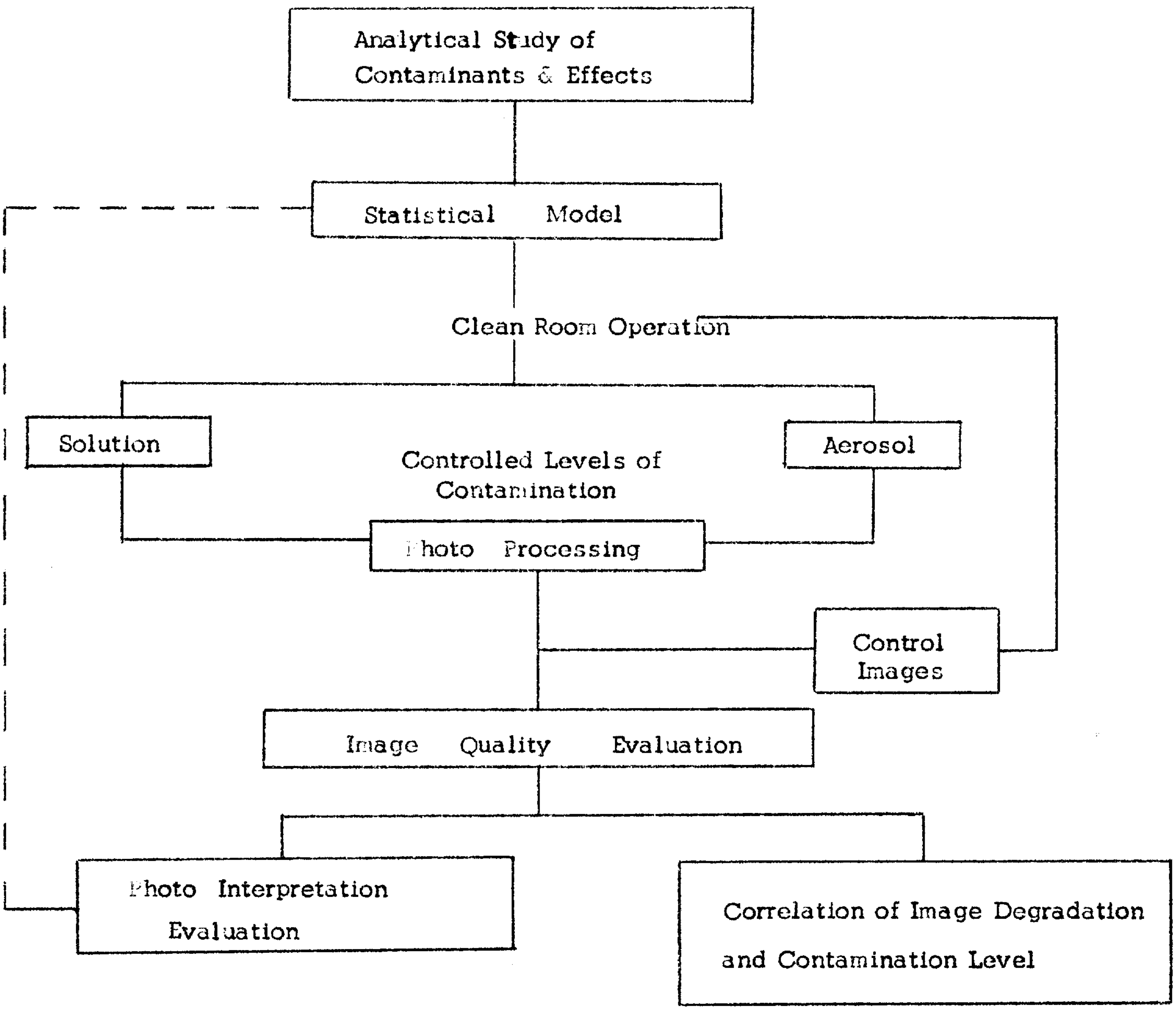
r) Prepare instructions and transmit complete forms to computer facility.

s) Punch cards, process, and printout results at computer facility.

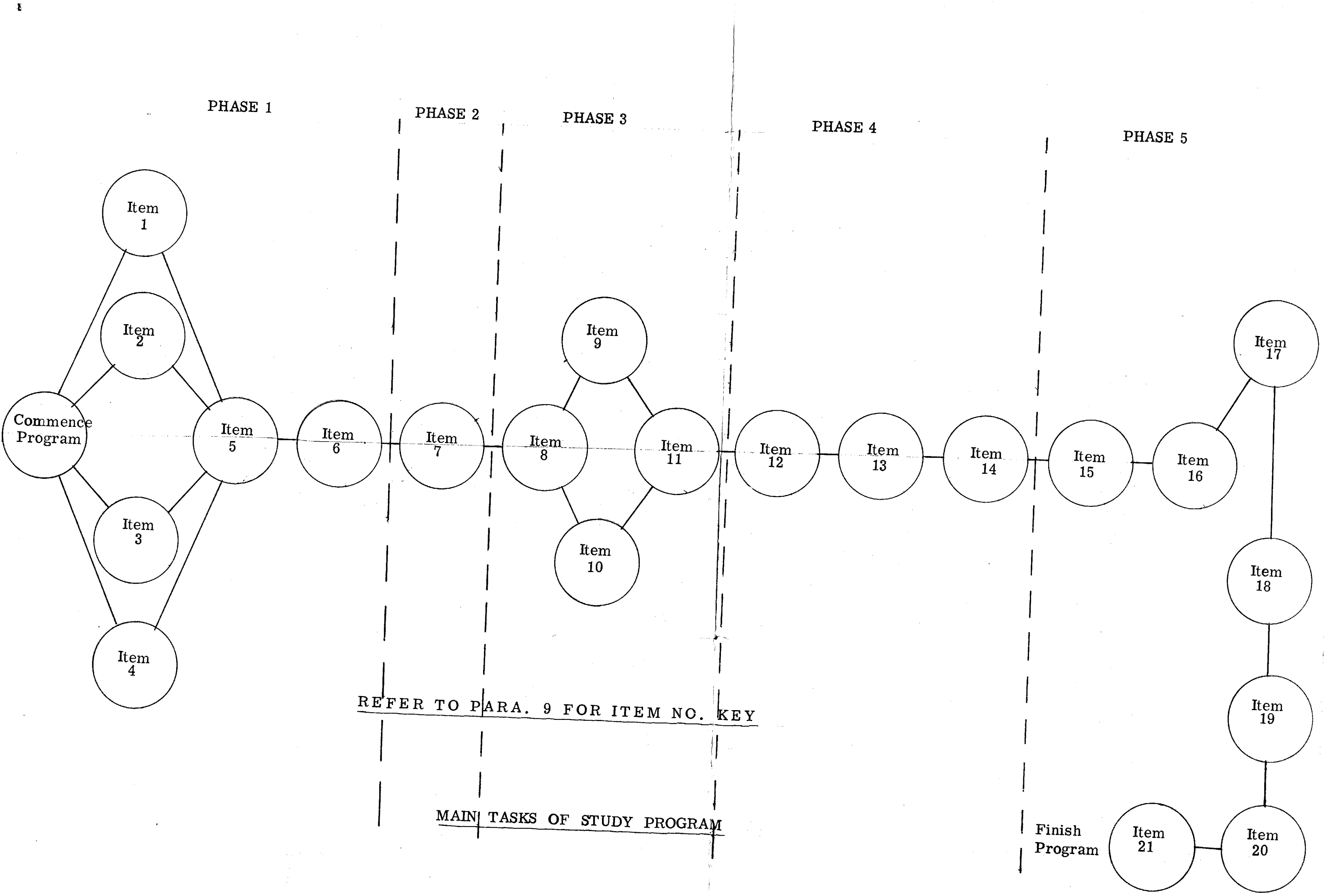
t) Receive computer printout, evaluate results.

v) Write final report.

PROPOSED ANALYTICAL STUDY INTO EFFECTS OF CONTAMINATES ON PHOTOGRAPHIC FILM



Program Summary Fig. 1



MAIN TASKS OF STUDY PROGRAM

FIG. 2

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RESEARCH LABORATORY PROGRAMS

The research laboratories were constructed, and the clean room complex erected by funds obtained from a Government contract. This first stage of this contract consisted of two major sections, the preparation of the area, erection of the clean room complex and finishing of the area, and secondly, a research program in which the following projects were worked on.

(1) Liquid bearings, hydrodynamic and rotary.
(2) Air bearings. Tunnel type and rotary.
(3) Vacuum capstan, positive and negative pressure source.
(4) Evaluation of pressure losses in standard pipes and fittings.
(5) Determination of force required to bend film.
(6) Sensitometric studies into the effects of elevated processing temperatures and shortened times on aerial emulsions.
(7) Efficiency of temperature control systems.
(8) Conception of modulated film processor.
(9) Determination of the coefficient of film drag.

In the current program, work on items 1, 2 and 3 is being completed. In addition to these, the following new programs have been approved.

(10) Accelerated development by heat-shock.
(11) Studies into improved methods of film drying.
(12) Continuation of sensitometric studies.

Additional programs now being actively sought, are an analytical study of the effects of contamination on image quality and photographic interpretation, and a program to determine the performance of dry process film emulsions. In this field, we have, in conjunction with the company concerned, already covered enough ground to be able to predict a line of hardware. In other areas described in the following summaries, varying degrees of work have been accomplished. In the case of the lead iodide process, for instance, we have successfully deposited films on glass substrates and are awaiting time and the opportunity of an optical bed to enable image exposures to be made. In the instance of the use of lasers, we are cooperating with the Korad Laboratories to assess the use of a laser beam in image quality reading. In all other projects, some efforts have been made and a number of proposals have already been prepared.

In consideration also for immediate preparation are proposals to up-date the HTA/5, qualify the ABD4 and evaluate and if possible (in conjunction [redacted] convert the 4 x 5 chip processor for other purposes. 25X1

In the commercial field a study is being made of the requirements of setting up an equipment qualifying and evaluation service, and an industry wide sensitometric and laboratory service. A commercial brochure for this purpose is in rough layout.

AN UNIQUE APPROACH TO INFLIGHT PROCESSING

As military tactical strategy and logistics demand closer to realtime processing for immediate post-strike analysis, emphasis has been shifted to inflight processing. This proposal, then, suggests research aimed toward two goals, 1) the production of an extremely high-speed processor, rugged enough to withstand rough operational conditions, simple enough for relatively untrained operators to load and control, but still capable of producing original negatives of archival quality and, 2) film suitable for use in such a processor.

Sufficient preliminary experiments were performed to establish the feasibility of the following performance parameters:

(1) Processing cycle under 5 seconds.
(2) Development uniformity.
(3) Wide processing temperature latitude: $70^{\circ}F \pm 20^{\circ}$.
(4) Wide processing time latitude: 5 times nominal time.
(5) Small volume solution requirements.
(6) Extended solution life from contamination or storage. considerations: Minimum of three weeks.
(7) No chemical fog.
(8) Increase in effective film speed.
(9) No sensitometric degradation.
(10) No subject image degradation.

The principle involved is to incorporate a non-active fraction of the developer in the film's emulsion, together with the photosensitive silver halide. After exposure, the latent image is developed by activating the inert portion of the agent with an accelerator and subsequently stabilizing the image. High viscosity reagents are used throughout to avoid the inflight problems of leakage under maneuvering conditions of roll, pitch, yaw, evasive action, vibration and shock loads (landing, take-off, wind gusts, etc.). Another area to be investigated would be the incorporation of both the inactive portion of the developer and the accelerator in the emulsion (retained in a stable condition by microscopic encapsulation). Development would then consist of applying heat and/or pressure, thus approaching a dry-film process.

While much research and developmental work has been done by the industry to achieve the ideal completely self-contained inflight processor, no prototype now available promises both the speed of processing combined with archival quality, herewith possible.

HIGH VISCOSITY PROCESSING AND DE-VISCIDIZING

High viscosity (4000 centipoises or more) processing offers rewarding results such as extreme development speeds, small grain size, good resolution and gamma. The difficulties inherent in the process however, outweigh the advantages somewhat. By combining experience in the field of heat shock for rapid processing with the concept of viscous-layer development (and, of course, short stop and fixation), an ideal of minimum response time should be attainable. 25X1

One of the greatest assets of viscous processing, high speed, is, in itself, a problem. The developing action continues until removal of the viscous layer and subsequent short stop and, in the case of 15-to 20-second processing times, one second, plus or minus, becomes critical. If the viscous developer were not removed, but merely plunged into the short stop bath, activity would continue until the acid had permeated the viscous layer and neutralized the reaction at the interface boundary. The ideal solution to this problem would provide developer removal faster and more thorough than high-pressure water.

Two unique methods of de-viscidization of the solution retained on the film are proposed as potentially fruitful avenues of research. This program, therefore, investigates the use of de-peptizing agents or ultrasonic power to effect instantaneous devisciditization of the solutions permitting inter-bath transfer in the conventional manner. Concurrently, sensitometric studies are proposed to determine the parameters of operation, and the effect on image quality. The goal of this research program is the design of a very high speed processor employing the best features of deep tank immersion in a compact, efficient machine and having the simplicity of operation of Dr. Land's "Polaroid" technique.

LASERS

Many of the generators of coherent light, both solid state and gaseous, produce frequencies of wave length to which photographic films may be completely insensitive. Such a beam, then, could be used to scan the latent image on a film (ie. before development) and set the parameters for predictable gamma.

Another potentially fruitful line of research involves the use of lasers to produce an image quality meter operating on a new principle. Existent meters capable of reading gamma, granularity, acutance and resolution generally use a white-light source and very small apertures. Highly accurate readings depend upon extremely slow scanning speeds on the order of a few microns per hour.

Laser beams, on the other hand, being coherent, can be made to produce an interference pattern when bounced off, or transmitted through, objects of sufficient density to absorb portions of the light. Several simple optical systems can be made which will create this effect. Furthermore, the real and virtual images produced can be greatly magnified depending upon the optical system employed. After suitable scientific research, it is felt that the pattern of interference rings could be related directly back to the parameters it is desired to measure. At this point, a suitable scanner and electric eye could make a direct reading.

The inherent advantages of such a device are:

1) Instantaneous response.
2) Primary standard accuracy.
3) Less costly to build than present instruments.
4) Simplicity of operation.
5) Reproducibility of measurements.

Another allied field appears to be the possibility of producing three dimensional aerial photographs by this means. If a photograph of the interference patterns described earlier is made and the photographic transparency reilluminated with coherent light, the original object is recreated in 3-D. Thus, it might prove possible to combine two aerial views of the same terrain and project them into a 3-D image by this laser technique. The photo reconnaisance gains to be expected certainly would justify some work toward this goal.

LEAD IODIDE PROCESSING

This is a new process in which an image is recorded by the localized photo-decomposition of lead iodide. This project covers research into methods of depositing films on various substrates, methods of image recording, and determination of image quality. The process is intriquing to the research-oriented mind, because the grain size of the PbI_2-deposited layer is so fine that the image attainable approaches the resolution of the optical system used. The drawbacks of the material in its current early state of development are: (1) It must be sensitized at a temperature of $200^{\circ}F$. 2) It is photographically slow, and 3) It is soft and subject to abrasion. These shortcomings merely offer research challenges comparable to those faced in the early history of silver halide experimentation. Nothing was published on the phenomena prior to August, 1964, when the findings of a research group at the University of Bristol, England were recorded.

The first significant breakthrough in photographic paper improvement occurred when silver bromides and iodides were substituted for the slower halide, chlorine. This certainly demands first priority in research attention. These remains also the possibility that the process might be improved by the addition of certain catalysts to speed up nucleation, or other heat sensitive, photon-reacting combinations such as the diazonium photopolymers.

The material offers such a number of distinct advantages over other microfilm recording medio that it deserves research investigation in depth.

HIGH-TEMPERATURE, HIGH-SPEED SENSITOMETRIC PROCESSOR

Studies of the effect of elevated temperatures on negative aerial emulsions are currently being conducted. One of the parameters of this project is the increasing of the processing temperature, and the decreasing of the corresponding processing time. At the present time, a temperature of 118°F has been reached with a processing time of 15 seconds. Due to human limitations, it has been found impossible to shorten this time with currently available apparatus. An analysis of the requirements of a laboratory type processor, shows that a processor of the type required is not available. The need lies in a small compact research machine capable of operating over a wide range of both time (20 runs to 1/2 second or less) and temperatures (68°F to 95°F) and designed specifically for clean room use. The processor should also be capable of reproducing the many methods of agitation normally used, since much of the published photographic processing data issued by leading film manufacturers does not state the method of agitation employed when conducting the original photographic experiments to determine the sensitometric characteristics of any one emulsion and its response to a given developing formula.

Other features required in such a laboratory tool, is a duplication of all methods of processing, daylight operation, continuous belt transport system, small quantities of solution, high viscosity capability, heat shock application provision, variable agitation to include spray, immersion, turbulation bars, nitrogen burst, liquid bearing etc. The dry box must be provided with per cent relative humidity control. Such a sensitometric processor it is believed would find ready acceptance in many fields of photographic research and production laboratories throughout the country.

DRY PROCESS REPRODUCTION

All government agencies currently involved in photographic processing are beginning to evince interest in dry film and non-silver reproduction. The burden of research, more over, is intensified because of the current world shortage of silver (in 1964, usage was over twice total production).

These non-silver photo sensitive materials include blueprints (ferrocyanide-ammonia), electrostatics, diazonium-photopolymers, etc. The Eastman - RCA "Bimat" is a silver-halide dependent process which, in the technical sense, is not a "dry" process. Development is achieved by bringing a film, pre-soaked with processing solution, into intimate contact with the exposed negative. Diffusion is augmented by pressure rollers. The process is thus similar to the Polaroid viscous paste technique, but is much slower, its speed being in the range of 1-inch per minute.

A new technique, which should be capable of producing non-silver images at moderately high speeds, is now proposed. Using the recording technique discovered a few years ago by General Electric, that of creating interference patterns in thermoplastic film by applying heat, this could be achieved. This research program however, suggests using a modulated laser beam as the distorting source, rather than a hot wire. Thus, higher speeds would be achieved while, at the same time, greater resolution should be possible because of the small diameters attainable in beam width. An added advantage of this process is that the film might prove to be reusable, if archival retention were not required. Reheating the recording film, causes plastic flow and the elastic memory returns it to its original smooth surface.

A research proposal covering investigations into lead iodide and lead bromide (another photo-and heat-sensitive, dry process) is presented in another section of this outline.

Thus, as military tactical strategy and logistics demand closer to realtime processing so that post-strike analysis can be immediate, primary research effort is forced into two channels. Reduce the processing time for the original negative (perhaps, by inflight development) and secondly, reduce the time now required for producing duplicates of the original. [redacted] 25X1
[redacted] preliminary investigation has already proven the feasibility of 25X1
producing high quality prints while development is still in process. This opens the door for a whole new research endeavor, outlined below:

continued

DRY FILM PROCESSING PROGRAM

1. Determination of silver halide image quality relationship to diazonium-photopolymer image quality.

2. Viewer Printer (Non-reversing)
   a) 70m/m to
   b) 2-1/2 in.

3. Viewer Printer (Reversing)
   a) 70m/m to
   b) 9-1/2 in.

4. Viewer Printer Enlarger (Reversing)
   a) 70m/m to
   b) 9-1/2 in.

5. Viewer Printer Enlarger (Non-reversing)
   a) 70m/m to
   b) 9-1/2 in.

6. Print Copies.
   a) Up to 11 x 17 in.

7. Investigation to assess possibility of combination of silver/halide and diazonium-photopolymer to obtain fast dry processing direct from camera.

8. To determine the possibilities of producing color in diazonium-photopolymer type film.

ELECTROPHORESIS

Electrophoresis, or cataphloresis, literally means the movement of ions or suspended particles through a fluid under the action of an electromotive force (emf) applied to electrodes in contact with the suspension. Early Houston Fearless experiments in heat-shock techniques used a stainless-steel band in close proximity to the moving film. When heavy dc current, at low voltages, was applied to the band it heated, creating accelerated local development of the negative. It also quickly lost its close-tolerance adjustment due to plating out of silver from the film. This condition was subsequently eliminated by supplying alternating current to the bands.

There is every possibility that this dc-plating effect, deleterious in the case of heat-shock, could be used advantageously to accelerate development. Since the main chemical purpose of a developer is to dissolve non-activically activated silver ions, any process enhancing this action will speed development. If, then, a negatively-charged, moving electrode were placed close to the film and the latter given a positive charge, silver ions (which have a positive charge) would migrate rapidly toward the cathode. The potential would, of course, be adjusted to a lower level than that at which disintegration of the developer would take place. The migration would take place most rapidly in the areas of greatest density, ie. the shadows, which is the desired effect.

An added advantage of this process should prove to be smaller grain growth due to the decreased total time in the developing solution. Clearing time should likewise be reduced due to fewer remaining undissolved and removed silver salts in the emulsion.

The moving electrode would be continuously scavenged of its collected silver by a second electrode, so that the space between the film and the cathode could remain constant. Here, then, is a proposed process which promises to improve response time while concurrently producing a valuable by-product, pure silver.

DEVELOPER LUMINESCENCE

During tests made in connection with the design of a processor, ultrasonic agitation was experimented with. During this agitation it was noted that the developer (D-16) exhibited a marked luminescence. It would appear that the investigation of this phenomena would be a rewarding area of investigation. Some of the logical reasons, are:

1. A basis for real-time chemical analysis of developers.

2. Automatic control of replenishment if the luminescence is proportional to the chemical activity of the developing agents.

3. If the luminescence wavelength and intensity do increase exposure levels of silver halides, then controlled amounts of luminescence could be used to produce intensification of the latent image.

4. If vibration (ultra-sonic or sonic) produces luminescence over a wide range, then these data would become important in airborne or satellite processing areas, where processing chemicals may be subjected to ultrasonic vibrations during launch or in flight.

5. If on measurement, the luminescence does not increase or promote fogging of silver halide emulsions, then perhaps the light output could be used for visual monitoring of processing operations.

It is believed that this phenomenon has never been thoroughly investigated with regard to photographic materials and processing. Research into this area might well result in advances in the state-of-the-art.

ULTRASONICS

Besides the proposal to use ultrasonic transducers to de-viscidize highly-viscous processing chemicals (described under "DE-VISCIDIZING"), two more areas worthy of research exist. These are: 1) A squeegee and 2) A developer accelerator.

During early [redacted] experimentation with air knives, or squeegees, to remove surface liquids from the film without injury to the emulsion, a phenomenon was noted. At certain high velocities, a high-frequency flutter would develop as the film passed through the knife. When this occurred, water removal was much faster and efficient, as might be expected. There is every reason to believe that ultrasonics could do as well, if not better, in this application. One distinct advantage would be the fact that ultrasonics are much easier to shield from the operator than the high-pitched, siren-like wait of an air knife, which makes it extremely unpleasant to work near. 25X1

In past experimentation, it has been well established that many chemical reactions, particularly those requiring diffusion for completion, are accelerated by the addition of ultrasonic energy to the reaction bath. This should be especially applicable to the photographic process. A series of tests should be run appraising the effect of ultrasonic energy on rate of development, image quality, granularity, etc. and similar effects in the case of short stop, fixation, and washing. There is the distinct possibility that all other standard forms of solution agitation might be eliminated, particularly important in some of the industry's latest compact processors. Some of the newest solid-state transducer power supplies are smaller physically than the fractional horsepower motor and pump units currently used in these processors.

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SPRAY PROCESSING COLOR FILM

Despite its inherent advantages of speed, economy, controllability and compact processor permissibility, spray processing of color film has never reached reduction to practice. It is felt that none of the recognizable problems would be resistant to a concerted research effort.

Some of the outstanding difficulties, such as aerial oxidation (more critical in its effect on color film than it is on black and white) appear relatively easy to overcome. Others, such as the differential diffusion rate of the processing chemicals through the different color-sensitive layers of the emulsion, offer more challenge. Since the foregoing phenomenon causes a color imbalance in the final developed image, it is of critical significance.

In carrying out this proposal, research is indicated along the following lines. Altering the process chemistry to attain a proper pH gradient throughout the multilayer emulsion, is one approach. Another promising approach is that of introducing certain long-chain anti foggant polymers to the formulation to control the penetration rate through the various layers. Thus, it might prove possible to obtain color-balanced images by the same principle used in a series of particulate grading screens. A third avenue open is the use of "competing" developers which have the net effect of limiting the reduction of silver halide and, thus, preventing oxidation products from destroying the effectivity of the color couplers.

It is felt that the future importance and potential of this field are well worth extensive research effort now.

DEGASSING AND DE-OXIDIZATION OF PHOTOGRAPHIC SOLUTIONS

Close study is being given to the problems of exacting control of photographic processing, but in the area of the effects of developer oxidization little appears to be known. The primary factor in developer exhaustion other than direct usage is inherent in aerial oxidization. The oxidization products, besides drastically reducing developer life, may have an adverse effect upon the developing action. If anti-oxidants could be reduced or eliminated improvements in the photographic process would result, in addition to opening the door to new active developing agents. The project would investigate various methods of de-gassing and de-oxidizing solutions including the use of ultrasonics, the effect on emulsions, and the effect of the removal of anti-oxidants from developing solutions.

Other ramifications of this study are these. Numerous investigations over a period of more than 40 years have conclusively proved that developers will last almost indefinitely if the oxyphilic agent (hydroquinone, gallol, etc.) is kept separate from the caustic agent (sodium hydroxide, sodium carbonate, etc.). A spray processor should be investigated in which the two main constituents are intermixed in the correct proportion at the spray nozzle, itself. A similar system is used spraying two-component epoxy resins. Thus, storage life would be greatly extended and activity at point of contact, a constant.

Certain complex organic alcohols have been used to lessen surface evaporation from reservoirs by as much as 65 percent. Perhaps one of these might act as an oxygen barrier, when dispersed on the surface of the developing tank, without adversely affecting the photographic reaction. This type of preservative would be thoroughly investigated.

SUMMARY OF PROPOSED RESEARCH PROJECTS

APRIL 1965

R & D GROUP

25X1

FOREWORD

[redacted] was formed to meet the requirements of a government sponsored research program. This program defined objective peculiar to the development of the company designed air-liquid bearing concept of film processing. Because of the broad spectrum of disciplines represented by the group, many areas of research have been revealed during the assignments handled in this program since September, 1964. These areas which have been shown to be fruitful of separate research are outside the scope of the defined objectives of this program, but appear to offer state-of-the-art advances, or the development of needed specific items of equipment. The opportunity to submit study proposals on these projects would be welcomed as a means of broadening the activities of the group, to make possible even more significant technical advances.

25X1

SUMMARY OF PROJECTS.

1. HEAT SHOCK & DE-VISCIDIZING

High viscosity (4000 centipoises or more) processing offers rewarding results such as extreme development speeds, small grain size, good resolution and gamma. The difficulties inherent in the process however, outweigh the advantages somewhat. By combining [redacted] experience in the fields of 25X1 bearing design and heat shock with the concept of viscous-layer development, the goals of high load-bearing capacity and fast processing time could be attained simultaneously. This program would investigate the use of de-peptizing agents or ultrasonic power to effect instantaneous devisciditization of the solutions permitting inter bath transfer in the conventional manner.

This program thus details a research program to investigate the combined use of high viscosity solutions in conjunction with liquid bearings and heat shock. A unique method of de-viscidization is proposed to reduce the viscosity of the solution retained on the film. Concurrently, sensitometric studies are proposed to determine the parameters of operation, and the effect on image quality. The goal of this research program is the design of a very high speed processor employing the best features of deep tank immersion in a compact, efficient machine.

2. DEGASSING AND DE-OXIDIZATION OF PHOTOGRAPHIC SOLUTIONS.

Close study is being given to the problems of exacting control of photographic processing, but in the area of the effects of developer ozidization little appears to be known. The primary factor in developer exhaustion other than direct usage is inherent and aerial oxidization. The oxidization products, besides drastically reducing developer life, may have an adverse effect upon the developing action. If anti-oxidants could be reduced or eliminated improvements in the photographic process would result, in addition to opening the door to new active developing agents. The project would investigate various methods of de-gassing and de-oxidizing solutions including the use of ultrasonics, the effect on emulsions, and the effect of the removal of anti-oxidants from developing solutions.

3. LEAD OXIDE PROCESSING. This is a new process in which an image is recorded by the localized photo-decomposition of lead oxide. This project covers research into methods of depositing films on various substrates, methods of image recording, and determination of image quality. The process is intriguing to the research-oriented mind, because the grain size of the PbI_2 deposited layer is so fine that the image attainable approaches the resolution of the optical system used. The drawbacks of the material in its current early state of development (1) It must be sensitized at a temperature of 200°F, 2) It is photographically slow, and 3) it is soft and subject to abrasion) offer research challenges comparable to those faced

in the early history of silver halide experimentation. Nothing was published on the phenomena prior to August, 1964, when the findings of a research group at the University of Bristol, England were recorded.

4. PRINT DROP-OUT.

Discussions with veteran photographic interpretation staff members, suggest that a need exists for a method whereby a negative or positive copy of a film frame (particularly in 9 1/2 ins. widths) could be immediately obtainable while the negative film is still in process. This project would evaluate various media, including ultra-violet sensitive emulsions for suitablility, and propose various methods of producing such prints, either as an addendum to a processing machine or as a separate assembly to be fitted on. Various methods of control are envisaged, such as providing a remote T.V. to enable a monitor to select a particular image for copy and immediate inspection by operating a simple push switch. Other alternative methods could provide for prints on a selected time span (and therefore footage) basis, or as a result of continuous viewing at the take-up end of a processor. The objective is to permit an immediate inspection of a frame of a film while the remainder is still in process. The resolution is to be such that the positive or negative copy is within the normal photographic interpretation range for the particular imagery. Such a proposal is in the realm of scientific feasibility due to recent improvements in heat-developable emulsions.

5. DEVELOPER LUMINESCENCE.

During tests made in connection with the design of a processor, ultrasonic agitation was experimented with. During this agitation it was noted that the developer (D-16) exhibited a marked luminescence. It would appear that the investigation of this phenomena would be a rewarding area of investigation. Some of the logical reasons, are:

1. A basis for real-time chemical analysis of developers.

2. Automatic control of replenishment if the luminescence is proportional to the chemical activity of the developing agents.

3. If the luminescence wavelength and intensity do increase exposure levels of silver halides, then controlled amounts of luminescence could be used to produce intensification of the latent image.

4. If vibration (ultra-sonic or sonic) produces luminescence over a wide range, then these data would become important in airborne or satellite processing areas, where processing chemicals may be subjected to ultrasonic vibrations during launch or in flight.

5. If on measurement, the luminescence does not increase or promote fogging of silver halide emulsions, then perhaps the light output could be used for visual monitoring of processing operations.

It is believed that this phenomenon has never been thoroughly investigated with regard to photographic materials and processing. Research into this area might well result in advances in the state-of-the-art.

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6. HIGH-TEMPERATURE, HIGH-SPEED SENSITOMETRIC PROCESSOR

Studies of the effect of elevated temperatures on negative aerial emulsions are currently being conducted. One of the parameters of this project is the increasing of the processing temperature, and the decreasing of the corresponding processing time. At the present time, a temperature of 118°F has been reached with a processing time of 15 seconds. Due to human limitations, it has been found impossible to shorten this time with currently available apparatus. An analysis of the requirements of a laboratory type processor, shows that a processor of the type required is not available. The need lies in a small compact research machine capable of operating over a wide range of both time (20 runs to 1/2 second or less) and temperatures (68°F to 95°F) and designed specifically for clean room use. The processor should also be capable of reproducing the many methods of agitation normally used, since much of the published photographic processing data issued by leading film manufacturers does not state the method of agitation employed when conducting the original photographic experiments to determine the sensitometric characteristics of any one emulsion and its response to a given developing formula. Other features required in such a laboratory tool, is a duplication of all methods of processing, daylight operation, continuous belt transport system, small quantities of solution, high viscosity capability, heat shock application provision, variable agitation to include, spray, immersion, turbulation bars, nitrogen burst, liquid bearing etc. The dry box must be provided with per cent relative humidity control. Such a sensitometric processor it is believed would find ready acceptance in many fields of photographic research and production laboratories throughout the country.

With today's emphasis on inflight processing many systems have been devised utilizing the silver halide medium for rapid information transfer.

A study of the current rapid processing systems indicates the following problem areas, and resultant information loss.

Saturated Web Processing

The saturated web processing application method has had limited success where the development time is in excess of one minute at an elevated temperature of approximately 120°F. However, in considering the web process for rapid access, the following characteristics will be present.

(1) Imprint pattern of the web material

(2) Non-uniformity of application of film sizes in excess of 35mm

(3) If the film is not developed in one continuous operation, the web will dry out in the areas adjacent to the film previously developed.

(4) Air inclusion: Extreme difficulty is encountered in achieving good contact in all areas of the format to be developed.

(5) The web imprint by subjective viewing appears to be similar to either a reticulation or graininess pattern. The process will produce higher fog than normal, lower maximum density than normal and lower gamma. There is a possibility of subsequent film speed loss.

Viscous Processing

(1) Extreme difficulty encountered in uniformity or evenness of application. Thus, resultant image is not uniformly developed or exhibits mottled appearance.

(2) At normal temperatures the processing time for this method is extremely long. If the development solution temperature is elevated above 120°F, extreme difficulty is encountered in the development-rate cycle (transfer of development by-products out of the emulsion, and replacement by fresh developing agents into the emulsion).

(3) In considering viscous processing for rapid information access a monobath solution is required. A monobtah solution in the viscous state will yield a high fog level, a lower maximum density, and subsequently lower gamma.

Since the above processing methods have their limitations, much thought has been devoted to the feasibility of an extremely high-speed processor which will enable the processing temperature to remain at the 70°F level with a complete processing cycle under 5 seconds. The most important design feature is to produce an image comparable to a conventional process. The method of rapid processing this proposal would research is one in which either the complete or partial development chemistry is incorporated within the silver halide emulsion. The latent image would then be processed by first activating the developing agents that are incorporated in the emulsion, followed by a chemical stabliizing treatment.

Preliminary experiments in development used Ansco's commercial liquid silver halide emulsion prepared for coating on 11" x 14" photographic acetate base material. The control standard series of coatings did not include developer chemistry. These control samples sensitometric and resolution tests were developed in Eastman Kodak D-19 and Rapid Foxer. The second set of samples had the incorporated developer chemistry introduced into the liquid emulsion prior to coating.

All photographic tests were conducted using one inch wide film strips. The third experimental factor investigates the function of coating thickness in conjunction with incorporated developer chemistry.

The experimental results indicates that with the utilization of incorporated developer chemistry an extremely small process can be designed to produce the following performance characteristics:

(1) Processing cycle under 5 seconds
(2) Development uniformity
(3) Wide processing temperature latitude: $70^{\circ}F \pm 20^{\circ}$
(4) Wide processing time latitude: 5 times nominal time
(5) Small volume solution requirements
(6) Extended solution life from contamination or storage considerations: Minimum of three weeks.
(7) No chemical fog.
(8) Increase in effective film speed
(9) No sensitometric degradation
(10) No subjective image degradation.

The contact printed resolution test on both the control standard which was processed in D-19 $68^{\circ}F$ for 4 min, and the incorporated developer emulsion was processed in an activator both for 4 seconds at $68^{\circ}F$. A microscope examination indicated equal resolution capability of 204 lines/mm.

It is strongly believed that the preliminary experiments justify an intensive research program to accurately establish the sensitometric characteristics of various emulsion formulas, and the image quality obtained in terms of granularity, fog, resolution, gamma and speed. If the research program resulted in a film image product the equivalent of those produced by conventional processing methods, a whole field of compact processors would become available for use in situations where the large conventional processors cannot be considered Some of these examples ready to mind are in-flight processors micro film processors mobile processing laboratories sporting events film processing, or in any situation calling for high speed, high resolution processing where space for the equipment is at a premium.

Micro D evaluation
Literature Survey - Dry Processes.
Facility
Prog Mgt (2)
Comm Coord
Prog under consideration
& group evaluation

(Not a formal problem solving)

PROPOSED SPONSORED

APPLIED DEVELOPMENT PROGRAMS

December 1965

25X1

INTRODUCTION

[redacted] research group was formed to meet the requirements of a government sponsored research program, which also included the design and installation of a clean room complex. Because of the broad spectrum of disciplines represented by the research group, applied research in many areas of film processing and image exploitation is possible, with the objective of the development of specific items of equipment as a means of continuing and broadening the activities of the group beyond the present contract which expires on December 31, 1965. Summaries of some of these areas are presented for evaluation and consideration. The opportunity to present full proposals on any of these projects will be welcomed. 25X1

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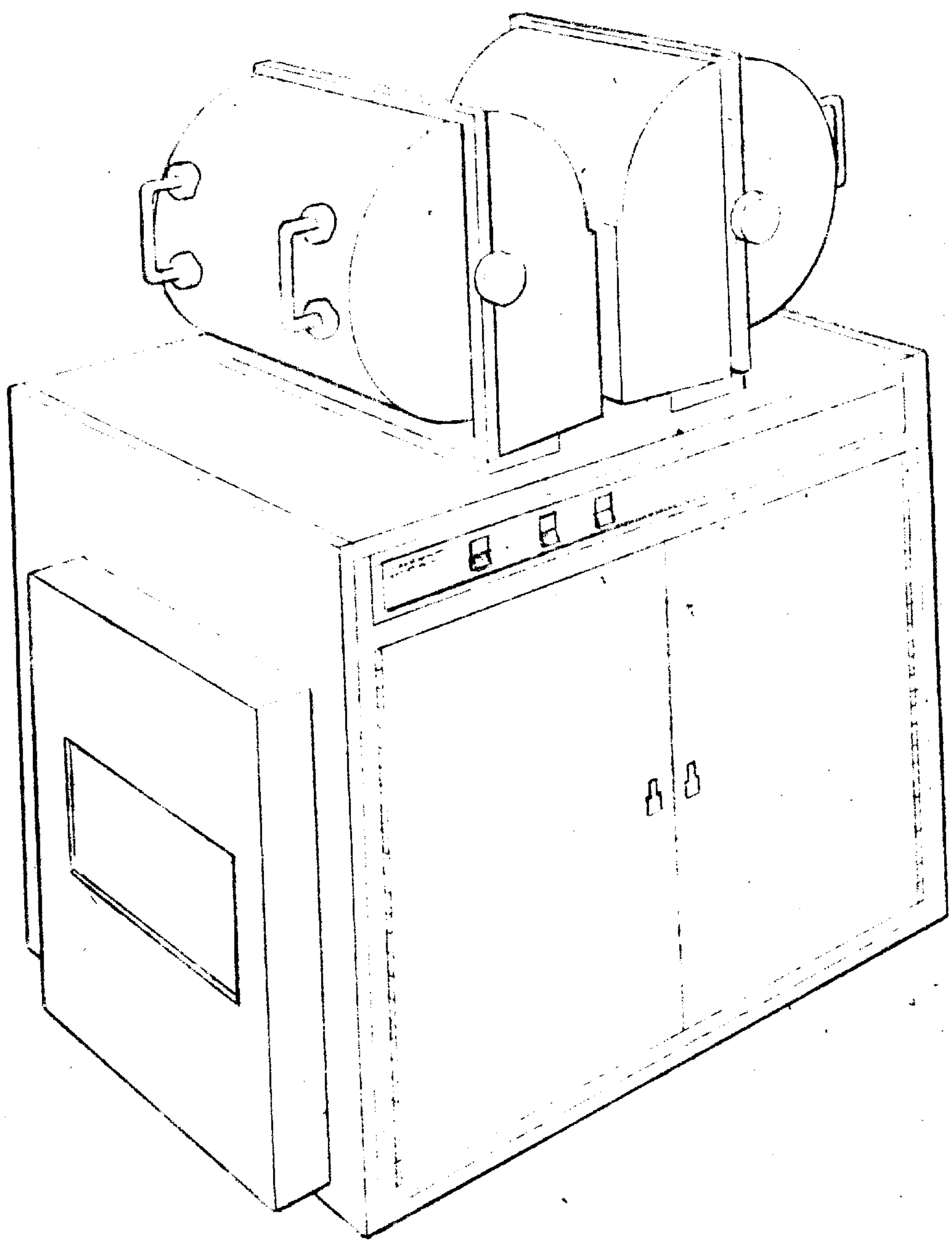
INDEX OF PROPOSED PROJECTS

1. A Tactical Continuous Printer *Koch*
2. Controllable Development *OK*
3. A Tactical Film Titler *Koch*
4. A Tactical 70mm thru 9-1/2" Film Processor *Koch*
5. Survey of dry film processing materials and design of equipment for use of Diazo, Kalfax etc. to achieve rapid access prints. *OK*
6. Acceleration of Image Development by heat shock (continuation of program)
7. Investigation of film drying techniques (continuation of program)
8. The adaptation of Houston Fearless Water Conservation System to current Air Force and Navy film processors. *Koch*
9. A rapid access enlarging printer with step and repeat capability.
10. A rapid access step and repeat contact printer.
11. A unique method of simultaneously achieving rapid access negative and positive silver halide images
12. Exposure compensation through dye absorption developer inhibitors.
13. High viscosity processing with de-viscidization
14. Negative- positive viewer

1. The [redacted] Tactical Printer is proposed as a continuous- contact printer that prints from a 70mm to 9-1/2 inch roll of either positive or negative transparency onto a roll of film-base or paper-base photo- sensitive (printing) material, and designed specifically for field use. 25X1

The Tactical Printer would consist of an enameled light-tight cabinet on which are mounted light-proof cassettes for supply and takeup spools of the duplicating film or paper. The supply spool has a drag clutch and the takeup spool has a torque motor to insure positive transport and registration of the duplicating materials. The interior of the cabinet houses the film transport mechanism and the printing light source. The elements of the film transport mechanism are the transparency supply and takeup spool adjustable supportw, two torque motors, and a driven metering roller. One torque motor drives the original stock supply spool shaft; the other drives the original stock takeup spool shaft and the metering roller for the duplicating stock. A control for slewing the original stock and a viewer located on the left side of the printer permit preselecting any frame or group of frames to be printed. A voltage adjustable 40 watt incandescent lamp provides the printing light source. Neutral density filters added to the exposing aperture permit finer exposure control.

The printer may be daylight operated from any 115 volt, 60 cycle power source. Printing speed rate is 60 feet per minute. The transport mechanism will operate in the printing mode only if the metering roller shaft is pushed down to press the duplicating material in contact with the original material. Additional printing mode conditions include POWER switch set to ON, SLEW switch to FORWARD, and PRINT switch set to ON. The rewind mode requires the metering roller shaft to be raised, POWER switch set to ON, and SLEW switch set to REVERSE. Quick reference specifications are listed in Table 1.



[redacted] 'actical Printer

25X1

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Q-109-65

TABLE 1

SPECIFICATIONS

Material handled	70mm to 9-1/2 inch wide negative/positive roll film 70mm to 9-1/2 inch wide duplicating film or 9-3/8 inch wide paper
Material Capacity	Original stock, 1000 foot spools Duplicating stock, 1000 foot spools
Resolution	80 lines per millimeter minimum
Operating Speed	60 feet per minute
Operating Area	Daylight
Slewing Capability	Original stock only
Viewing Window	8-1/2 by 4-1/2 inches
Dimensions	Length 25 inches Width 33-1/4 inches Height 24-1/2 inches (without magazines)
Weight	–
Power Requirements	115-volt, 60-cycle ac

2. CONTROLLABLE DEVELOPMENT

A. The heat shock program, marks but a small inroad into a field as vast and complex as "latensification," or the study, measurement and intensification of the latent image while still in the process of development. Many different films (both original negative and duplicating stocks) must be studied in combination with different developers and processing rates.

B. Either infrared or laser scanning could be coupled with image analysis to provide point-to-point control of the development process. Natural outgrowths of this study would be direct sensor control of local heating, local latensification with active light, local Hershel-effect erasure and feedback control of chemical activity. The upper limits of latensification are not known to the photo scientific field and should be determined as these data are as basic to problems in modern photography as the work of Hurter and Driffield was for its day.

C. Chemical Auto-Compensation

Aside from scanning the developing image and controlling further development, there is another possible approach for exposure compensation. This method is "Chemical auto-compensation." This method is entirely automatic, in that the image itself controls the further development of the film. Furthermore, this method results in point-by-point compensation of the image.

I) "Starvation Development"

By using a viscous developer with a low concentration of developing agent, development of the overexposed areas will be limited by the lack of available developing agent. Used in conjunction with a longer-than-usual developing time, the underexposed areas will become over-developed while the overexposed areas will remain underdeveloped.

Similar results are achieved by initiating development in an ordinary non-viscous developer, then allowing development to reach completion in a stationary water bath.

These methods have been investigated in the past, but never in regards to exposure compensation.

5. SURVEY OF DRY FILM PROCESSING, MATERIALS AND EQUIPMENT

The ease and cleanliness of dry film (and semi-dry film) processing together with the advantage of employing relatively untrained operators, has always intrigued both science and industry. Recently, the world-wide shortage of silver and the scarcity of fresh water supplies have combined to greatly increase the pressure for scientific exploitation of non-silver halide processing. The net result of this unique set of circumstances is that a bewildering plethora of papers, films, processors and techniques are now available.

Since much of this developmental work is proprietary in a highly competitive field, a complex of patents, trade secrets and mystery shrouds the products and inhibits an unbiased appraisal of the best process to use for a given application. What is needed, then, is a complete survery in depth of every process and material now on the commercial market by a scientific laboratory unbiased by the possibility of a conflict of interests.

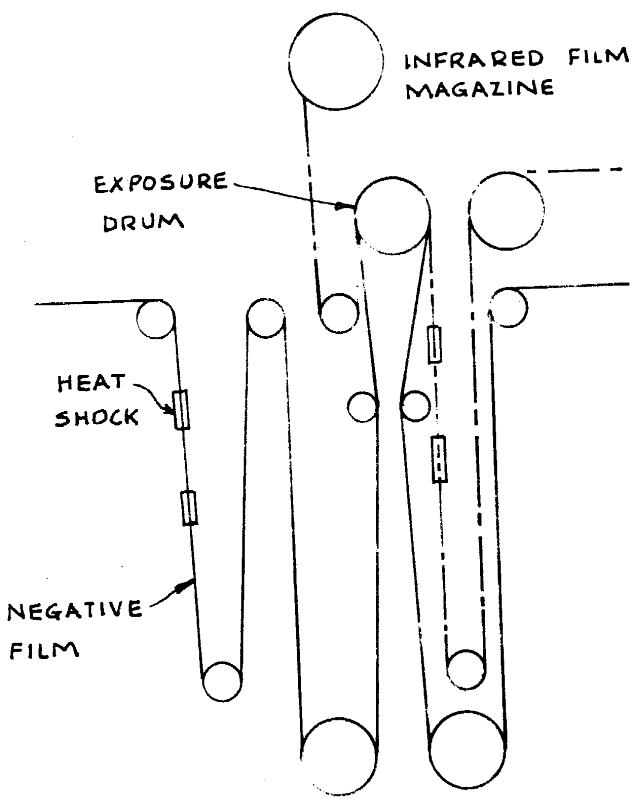
Such an exhaustive research project would produce immediately not only the parameters necessary to permit selection of the best technique to use for a given application, but also bases to predict possible limitations of products when only the technical requirements of a new need are known.

Only on the basis of such a correlative survey as proposed above, would it be possible to find the gaps in existent equipment and predict functional gear scientifically within the state-of-the-art. Such a survey could reveal many fields in which silver halide could be superceded by one of the dry film processes with its inherent advantages. Also, it can be expected that data will be obtained that will predict whether existent commercial or military equipment can be used directly, or modified to encompass these products.

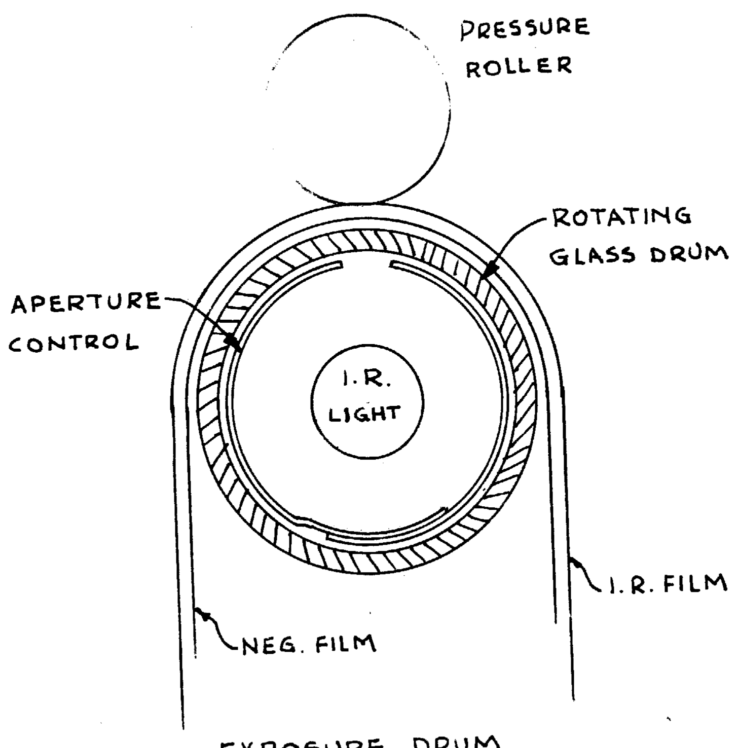
6. <u>ACCELERATION OF IMAGE DEVELOPMENT BY HEAT SHOCK - CONTINUATION OF PROGRAM</u>

The research program initiated for the first half of fiscal 1965 (July - December) to advance the state-of-the-art produced by pioneering efforts of [redacted] engineers in image enhancement by heat shock is showing good results beyond those expected in this early stage of the program. Stable images have been produced in which density has been raised from 3 stops under normal exposure to normal without discernable grain growth or loss of resolution. 25X1

By the expiration date of the present research program, all criteria on all aerial emulsions will not have been obtained from the experimental processor nor the data reduced to permit a final analysis of performance and application concepts to be prepared. It is proposed that this program be funded to permit the outstanding work on black and white films to be completed and to further investigate the use of heat shock in conjunction with special chemistry to speed up color film processing.



FILM PATH ARRANGEMENT



EXPOSURE DRUM

7. INVESTIGATION OF ADVANCED FILM DRYING TECHNIQUES - CONTINUATION OF PROGRAM

A program for the investigation of advanced film drying techniques is currently funded through December 1965. This program was initiated in September 1965 to investigate, by mathematical analysis and laboratory research, various methods of drying aerial photographic film with the objective or determining the design parameters of an advanced concept having a film handling capacity of 100 feet per minute or greater and of a smaller physical size than the large units now being used at lower film speeds.

The program to date has included the use of a moderate vacuum alone, vacuum and radiant heating, vacuum and low temperature drying. The use of solvents to increase the evaporation rate of water in the film has included both miscible and non-miscible (with water) solvents in conjunction with ultrasonic action to accelerate the diffusion of the solvents into the film emulsion. The use of an ultrasonic squeegee is also being tested for the removal of surface water. The preliminary analysis and testing has indicated that the most promising techniques to date to obtain the program objectives is the use of solvents with ultrasonic action.

Due to the limited time available before expiration of the current program, the thorough testing and analysis of all parameters will not be completed. Therefore, because of the established need for a high efficiency, high speed film dryer, a continuation of the program is proposed to complete the laboratory testing and analysis of results and to determine the design parameters upon which a prototype model may be based.

11. A UNIQUE METHOD OF SIMULTANEOUSLY ACHIEVING RAPID ACCESS NEGATIVE AND POSITIVE SILVER HALIDE IMAGES

A research study is proposed to determine the feasibility of simultaneously printing and processing both negative and positive images. In the proposed system, any of the commonly used negative films (i.e. 4400 - 4401 - 4404) would be developed to a gamma level which would permit the exposing of a positive image on infrared aerographic films.

The spectral sensitivity of both materials are such that with the proper filtration, the infrared film can be exposed to the far-infrared portion of the spectrum (800 - 900 M U) without effecting a panchromatic emulsion which loses its spectral sensitivity beyond 725 M U.

During the last stages of development of the negative image, the positive infrared material is exposed by means of a rotating glass drum housing the infrared light source. The infrared film is pre-wet in the developer prior to exposure, then during the exposing cycle both films are squeezed between the glass drum and a pressure roller. A minute amount of developer will remain between both emulsions to eliminate the possibility of sticking. The developer will also act as a liquid-gate system to achieve maximum resolution and image quality.

To synchronize the rate of develoment of both the negative and positive images, the technique of heat shock will be employed. Use of the heat shock applicators will also permit independent control of the gamma of either or both of the emulsions under development.

This technique could for example be employed by tactical air units utilizing 70mm camera systems to achieve rapid access images in less time than the conventional cycle of original negative processing, printing of positive images, and development of the same.

12. EXPOSURE COMPENSATION THROUGH DYE ABSORPTION DEVELOPER INHIBITORS

A unique method of exposure compensation is proposed, based on the inclusion in the developer of a dye-coupler molecule which will couple with the reaction products of development (e.g. bromide ion) to inhibit further development. The dye (white, or light colored) formed would deposit on the developing silver halide grain in direct proportion to the degree of developing action occurring; that is to say, where the greatest developing action is taking place, in the overexposed areas, the deposit would be heaviest with the reverse effect in underexposed areas.

The effect can be utilized in two ways, first the deposition of the dye on the overexposed areas will prohibit further development while permitting the development of underexposed areas to continue. Secondly, by the use of radiant (infrared) heat further control of development can be obtained since the infrared will be reflected from the heavily coated areas and absorbed by the uncoated areas. The action can be considered as the equivalent of the wearing of a white shirt in the summer to reflect the heat away from the wearer's body, as against the wearing of a black suit in the winter to absorb available heat. The result would again be the intensification of development in the underexposed (lightly or uncoated) areas due to the actions on the silver halide by the increased electro-chemical energy of the developer.

At the same time, due to the white dye coating both isolating these heavily coated overexposed areas from contact with developer, and by reflecting the infrared energy, development would cease or be retarded. The feasibility of this method has been proved by early research. A research program is proposed to:

a) Determine the chemical requirements and action of the dye and developers required.

b) Develop the infrared source required.

c) Determine the sensitometric criteria and performance of the system as a whole.

The [redacted] "Sepratron" concept of identical processing modules 25X1
lends itself to the application of such advanced methods of exposure compensation. The substitution of variously modified modules would permit accurate assessment of the results of such advanced methods as proposed above.

A further extension of the foregoing program would be research into the formulation of a developer that would have the property of negative Kinetic potential. This would be effected by the inclusion of a coupler molecule, which, in place of the formation of a dye coating, would couple with the reaction products of development to decrease the electro-chemical energy of the developer, thereby retarding development in overexposed areas. Conversely, development in underexposed areas, would be accelerated since a cessation or decrease in development inhibition would be effected due to the corresponding decrease in reaction products.

13. HIGH VISCOSITY PROCESSING WITH DE-VISCIDIZATION

High viscosity (4000 centipoises or more) processing offers rewarding results such as extreme development speeds, small grain size, good resolution and gamma. The difficulties inherent in the process however, outweight the advantages somewhat. By combining [redacted] experience in the field of heat shock for rapid processing with the concept of viscous-layer development (and, of course, short stop and fixation), an ideal of minimum response time should be attainable.

One of the greatest assets of viscous processing, high speed, is in itself, a problem. The developing action continues until removal of the viscous layer and subsequent short stop and, in the case of 15- to 20-second processing times, one second, plus or minus, becomes critical. If the viscous developer were not removed, but merely plunged into the short stop bath, activity would continue until the acid had permeated the viscous layer and neutralized the reaction at the interface boundary. The ideal solution to this problem would provide developer removal faster and more thoroughly than high-pressure water.

Two unique methods of de-viscidization of the solution retained on the film are proposed as potentially fruitful avenues of research. This program, therefore, investigates the use of de-peptizing agents or ultrasonic power to effect instantaneous de-viscidization of the solutions permitting inter-bath transfer in the conventional manner. Concurrently, sensitometric studies are proposed to determine the parameters of operation, and the effect on image quality. The goal of this research program is the design of a very high speed processor employing the best features of deep tank immersion in a compact, efficient machine and having the simplicity of operation of Dr. Land's "Polaroid" technique.

TECHNOLOGICAL ANNOTATION

Based on the latest published scientific advances in the field of photographic processing and technical papers from symposia describing individual research efforts, it can be safely predicated that technology must advance in a direction emphasizing viscous processing. Since fresh chemicals are always applied to the film and discarded after their function is complete, no replenishment is necessary and chemical control problems are eliminated. Agitation is likewise no problem as the gelatinoid layer remains undisturbed during the whole development treatment time. The degree and uniformity of development are, therefore, accurately controllable. As an added benefit, the chance of introducing environmental dirt are greatly reduced. The speed of development is such that, even at high film rates, the physical size of the machine can be a fraction of that of a deep-tank unit.

14. NEGATIVE-POSITIVE VIEWER FOR IMAGE INTERPRETATION AND PILOT BRIEFING

A program is proposed to develop a viewer using closed-circuit T.V. techniques to display aerial negatives to photo-interpreters, and remotely to groups of pilots, P.I. Officers, etc., by the use of additional T.V. monitors, or by large screen T.V. projection.

The following features are significant:

a) The display of negative film as a negative or as a positive, eliminating delay in printing.

b) A high definition over the whole viewed area.

c) The negative can be displayed laterally inverted, horizontally inverted, or 90°, 180°, or 270° rotated by the operation of a switch.

d) Any portion of the negative may be selected and "blown up" to fill the viewing screen without loss of picture definition.

e) The portion selected can be returned to at any time, since the translating controls would be calibrated.

f) Three magnifications can be provided, up to 10:1.

g) Contrast of the display image may be varied as required.

h) Rapid or slow film wind in both directions can be provided.

Further capabilities can be provided after development of the basic system, such as the following:

a) Instant prints or transparencies of any area could be obtained by the provision of a swing down Polaroid Land Camera.

b) Additional remote viewing stations could be provided, together with intercom stations at each with the P.I. station as the master.

c) To enable the photo-interpreter to see into shadows, highlights, and areas generally lacking contrast, tonal expansion contrast could be provided, in which a selected portion of the image gray scale could be expanded to cover most of the tonal range, and to increase the contrast of monotonic areas.

d) Image enhancement may be obtained by electrically differentiating edge gradients.

e) It is believed to be within the state-of-the-art to provide an image storage capability, wherein the image could be held and displayed over long periods while the film is being wound on for the examination of other targets.

f) Secondary viewing stations would be provided to enable the image storage to be effected.

g) Visual inspection of the film could be provided for by the addition of built-in side tables.

The system proposed would utilize proven techniques and equipment commercially available. The development would consist of system integration and design.

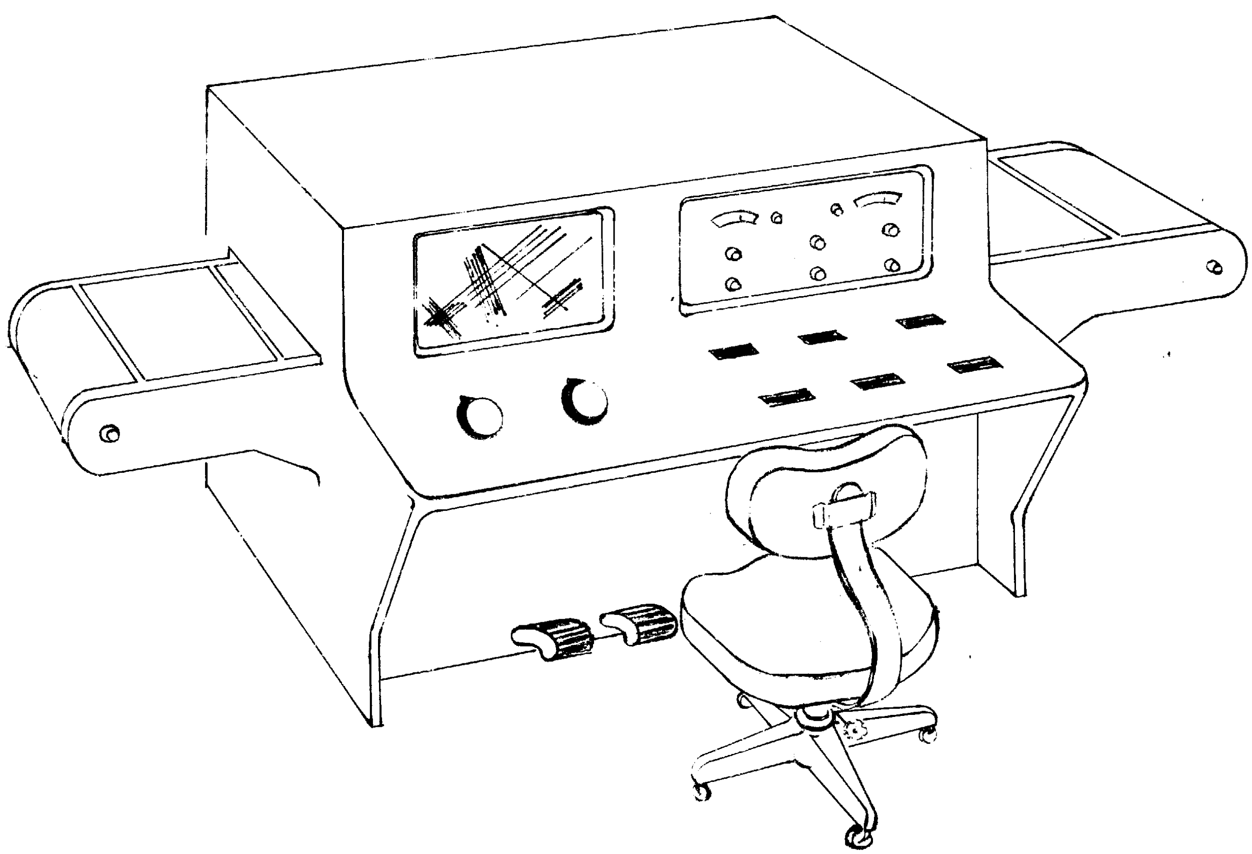


Figure 1. NEGATIVE - POSITIVE VIEWER -- ARTIST'S IMPRESSION

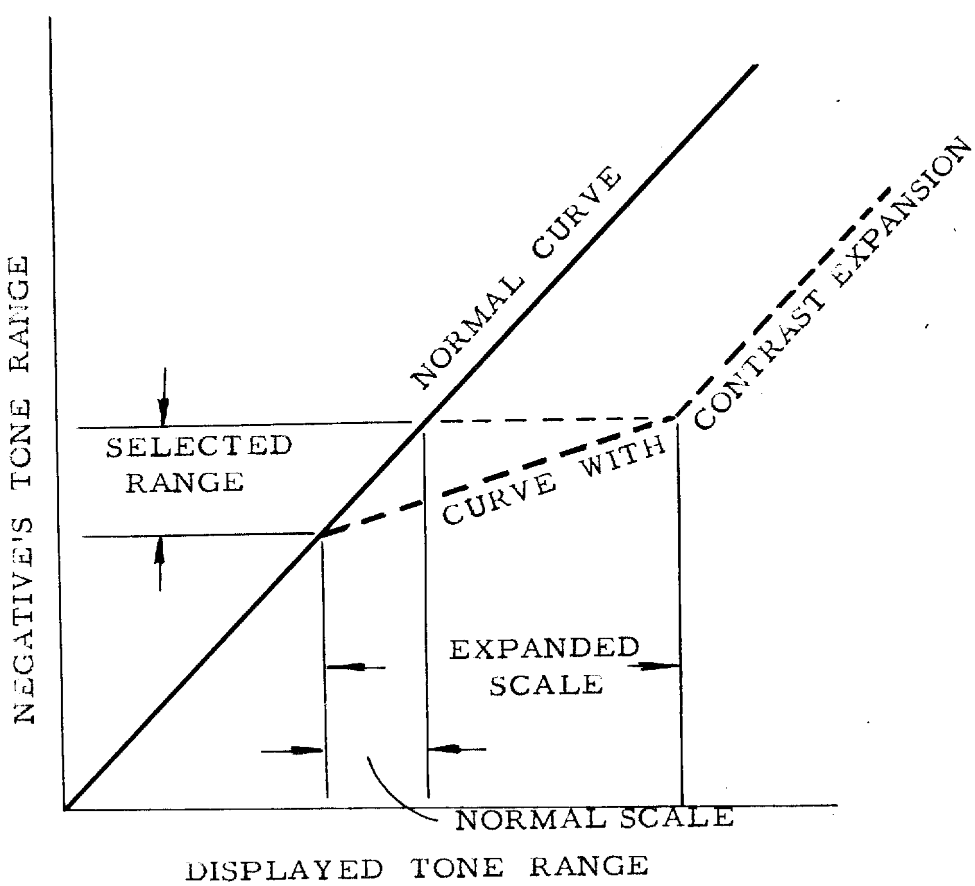


Figure 2. CONTRAST EXPANSION (IDEALIZED)

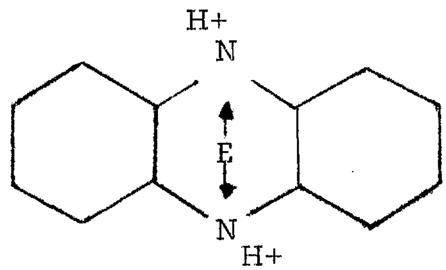
25X1

ADDENDUM TO MONTHLY REPORT

This report, the second in a series of investigations extra-curricular to current assignments was conducted to evaluate the effects of oxidation of developer solutions, and to determine if a research program based on removal and inhibition of oxygen from such solutions could be justified. The investigation was commenced with a literature research, the results of which are summarized below.

As early as 1882, Berkeley introduced the use of sodium sulfite in organic developers as an oxidation inhibitor. Since that era, a monumental amount of research effort has been expended to determine the exact action of sulfites in photographic developer and the beneficial and/or deleterious effects on the additive on speed and gamma. A number of the basic findings on sulfite reactivity are presented after this summary. To these can be added some specialized esoteric research results.

For example, in developing systems of the hydroquinone-quinone type, the electrochemical potentials depend greatly upon the pH of the solutions. They may be considered as determined by the concentrations of the oxidized form and of the divalent ion of the reduced form. If K_1 and K_2 are considered the first and second dissociation constants of hydroquinone, it can be shown that hydroquinone in alkaline solution absorbs oxygen at a rate proportional to the square of the hydroxyl-ion concentration below PK_1. The reaction is auto-catalytic because of the formation of the highly reactive semiquinone. Semi-quinoids are radicals in which one electron is shared by 2 atoms which possesses a septet of electrons each (alternated to an octet by the odd electron) as:



Michaelis and Hill found them stable only in moderately acid solutions in their potentiometric studies of the radical.

James and Weissberger in their 1939 studies of the mutually oxidation inhibitory reactions of hydroquinone and sulfite stated that the action of sulfite on hydro-quinone is not known. They experimented with cysteine, thioglycolic acid, thioglycolic anilide, p-thioresol and barbital as antioxidants. These foregoing additives are all more difficult to obtain, more expensive or less effective and/ or have more deleterious side effects than sodium sulfite.

In a classic study performed by Weissberger and Thomas in 1942, it was shown that silver catalyzes the decomposition of peroxide while the reaction of

(more)

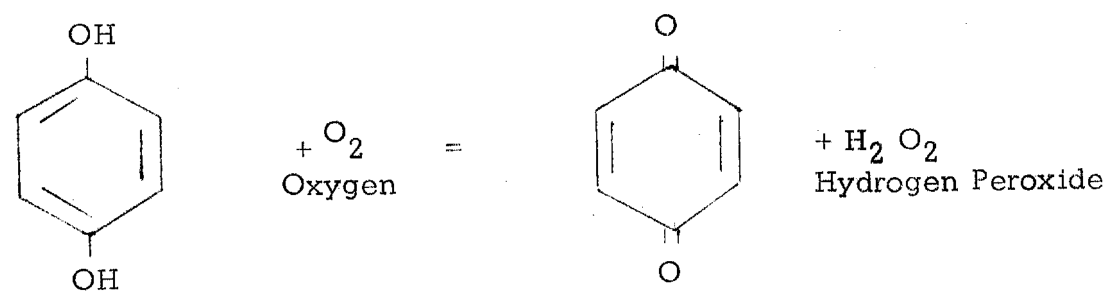
peroxide with developing agent is itself catalyzed by silver. Thus, was shown that the addition of silver strongly dimished the total amount of oxygen absorbed by the developing agents in alkaline solution.

In spite of the voluminous research which has been expended in just the last forty years, a cursory examination of typical hydroquinone-elon/metol formulations shows no significant change in the basic mixtures from the relatively primative photographic processing era to modern automatic machines.

The Function of Sodium Sulfite in a Photographic Developer

Sodium sulfite is a preservative that prevents oxidation. When a developer solution oxidizes, it tends to discolor, loses its activity, and stains the gelatin of the film. The addition of sulfite to developers produces the following effects:

1. Protects organic developing agents against aerial oxidation. The oxygen of the air readily attacks developing agents, as hydroquinone, converting them into two products, quinone and hydrogen perioxide.



Hydroquinone

Quinone

Small amounts of quinone may accelerate the reaction between hydroquinone and oxygen, by setting up a chain reaction. This reaction increases in speed as the quinone builds up. It is evident that if the concentration of quinone is allowed to build up, oxidation becomes more rapid and soon the developing power is destroyed.

When sulfite is present, this reaction is prevented. It reacts with the quinone rapidly converting it into a colorless soluble and harmless material. If sufficient sulfite is present in a hydroquinone solution, the quinone is used up about as fast as it is formed and little or none of it is left over to convert the hydroquinone into semi-quinone and accelerate the reaction of the oxygen. The ability of sulfite to act as a preservative may depend upon its ability to react rapidly with quinone.

2. Tend to prevent the formation of staining developer products. Without the presence of sulfite, staining developer products are formed in hydroquinone in two ways. As mentioned before, in the presence of oxygen it is converted into two products, quinone and hydrogen peroxide. Neither of these two

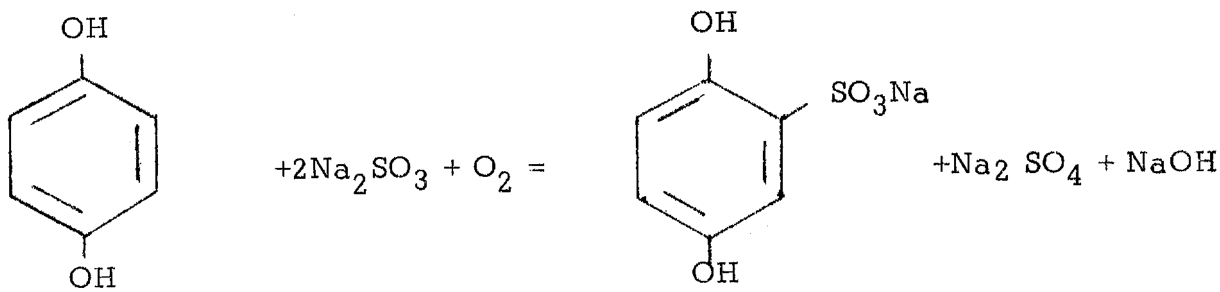
 (more)

compounds produce significant staining. Although produced by the same reaction, these compounds are not mutually compatible, the perioxide attacks the quinone converting it into another compound, oxyquinone.

Oxyquinone is highly unstable and almost instantly passes over into a brown insoluble material. If this brown material is formed within a photographic emulsion, it cannot be washed out and remains there as a stain.

For the second stain-producing reaction, the presence of oxygen is not necessary. When hydroquinone acts as a developer, the silver bromide is converted into silver. Simultaneously, the hydroquinone is converted into quinone. This time no peroxide is formed. But, quinone is unstable in carbonate solution, although not so unstable as oxyquinone. The oxyquinone again passes into a brown insoluble material, producing a stain on the film.

When sulfite is present in the solution, the series of reactions are able to progress only to the quinone peroxide stage, because sulfite reacts very rapidly with both. With peroxide, it forms sodium sulfate, a soluble, relatively inert chemical. With quinone it forms a compound chemically known as sodium hydroquinone monosulfate. This is a colorless compound that is soluble and produces no stain.



The sulfite prevents stain because it is easily able to remove the two stain-forming materials, quinone and peroxide.

The stain-preventing action of the sulfite does not carry over to the removal of stain once formed. The stain is not produced by the quinone itself but by an oxidation and polymerization product of the quinone. Sulfite will not convert this material into a colorless product.

3. Acts as a silver halide solvent by the formation of complexes. Sulfite exerts a solvent action on silver chloride and silver bromide. The sulfite ion forms a number of soluble complexes of the form $Na_{(n+2)} Ag_n (S_2O_3)_{(n+1)}$ (when n= 1, 2, 3, 4 and, perhaps more) with the silver ions.
This solvent action is of practical importance only with relatively dilute developer, or with developer of low alkalinity.

(more)

In fine grain developers, sulfite is used in a relatively high concentration. The solvent action takes place upon the surface of the silver halide grains preventing them from retaining their full size in development and reduces the tendency of the grains in close proximity to one another to merge and form larger clumps of silver.

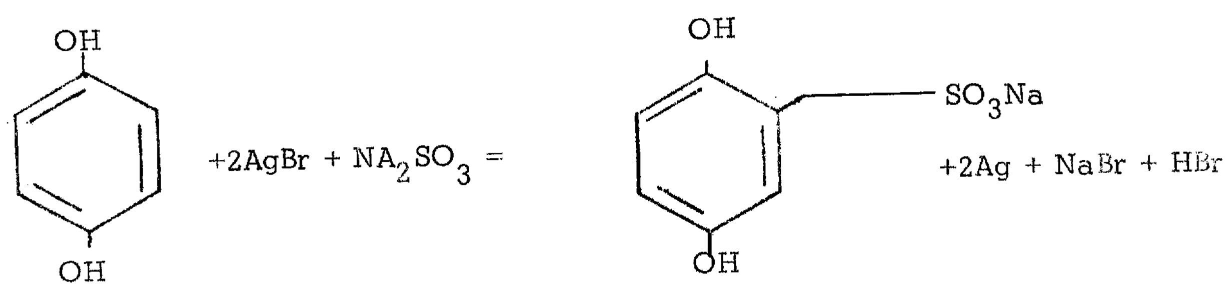
This action does not hold true in the use of all silver solvents. The use of a solvent can be overdone. Strong solvents produce an increase in graininess. The change in graininess produced by a solvent, also depends upon the emulsion in question. It is quite possible to obtain an increase in graininess with one emulsion and a decrease in another, the same addition of solvent to the developing solution being used.

4. Sodium sulfite is a weak alkali and under certain conditions, increases the rate of development and maximum density obtainable. Since sulfite raises the pH of the developer and accelerates the development in developers having a low pH, those having a high pH are affected slightly differently.

When added in large amounts to a developer composed of elon or hydroquinone, sulfite appears to retard development. A solution composed simply of hydroquinone carbonate and water will produce an image much faster than one containing sulfite. The reason for this is that sulfite, while it does not actually retard development, prevents the formation of oxyquinone, a material which otherwise would speed it up. What sulfite does do in this capacity is increase the maximum developer density obtainable for a given exposure. The cause of this increase is the dependence of the developer potential on the concentration of sulfite. As sulfite is added to the solution, the potential at first drops very rapidly and then more slowly. Since the density obtained for a given exposure varies almost linearly with the potential, it follows that the addition of small amounts of sulfite should increase the density greatly, as has been found to be the case.

5. Sodium sulfite also reduces excessive softening of the emulsion when high concentrations are used in a developing solution.

6. The reaction with silver bromide in the presence of sulfite follows the equation:



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Acid is liberated in this reaction, which accordingly tends to decrease the pH of the solution. The reactions of metol in the presence of sulfite follow similar courses. On the other hand, 1-phenyl-3-pyrazolidone ("Phenidone") does not form a sulfonate. The sulfite is not as effective as a preservative for Phenidone as it is for metol and hydroquinone.

Conclusions

Based on the findings of the investigation it is our opinion that a research program to determine the most effective means of de-gassing solutions in processing machines, and in chem-mix and storage tanks where oxygen entrainment is at a maximum is justified.

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Glass Type (Schott Type)#	Index of Refraction n_D	Dispersion	Dimensions: Diameter inches	Dimensions: Thickness inches	No. Pieces
BAF-4 Barium Flint	606 1.60562	439	12.3	1.8	39
BAF-9 Barium Flint	1.64328	47.8			
			9.0	2.0	2
			12.0	2.5	2
BAF-10 Barium Flint	1.67003	47.2	6.3	1.5	2
			8.35	1.5	2
BAK-1 Barium Crown	573	575	6.0	1.5	2
			8.35	1.5	2
			9.	2.0	1
			9.4	2.0	2
			12.0	2.5	2
BAK-2 "	540	596	6.35	1.5	2
			9.4	2.0	2
BALF-1 Light Barium Flint	563	509	6.0	1.5	2
			9.0	2.0	2
			12.0	2.5	2
BALF-6 "	589	532	6.3	1.5	2
			8.35	1.5	2
BF-1	517	385	6.0	1.5	2
			9 1/16	2.0	2
			12.0	2.5	1
			12 13/16	2 5/8	1
BK-1 Borosicilate Crown	1.51009	632 63.4	12.0	2.5	2
			9.0	2.0	3

Glass Type	Index of Refraction n_D	Dispersion U	Dimensions Diameter inches	Thickness inches	No. Pieces
BK-7 Borosilicate Crown	516	640	8.9	3.8	30
			9.3	4.7	45
			9.4	2.0	2
C-1 Crown Flint	KF 523	585	16 3/8	1.75	4
CF-1 Crown Flint	KF 529	516	6.0	1 3/8	20
		517	10.0	1 5/8	1
	530	518	11.0	2.75	1
	529	516	11 1/8	2.75	2
			11 3/4 x 11 3/4	3.5	3
			12.0 x 12.0	3.75	2
			12.0 x 11 7/8	3.25	1
			16.25	2 7/8	6
			16.25	3.25	5
			16.25	3 9/16	3
			16.25	4.0	9
			16.25	4 1/16	1
			16 3/8	4.25	3
			16.5	3.5	4
			16.5	3.0	5
			16.5	3.25	8
			16.5	3 7/8	3
			16.5	4.0	25
			16 5/8	3 3/16	1
	530	518	18 15/16	2.25	1
CORNING Dense 2 - Close to SK-16 [illegible]	620	603	9 3/8	1.75	12
			9 5/8	1 7/8	40
			9.81	4.27	7
	621		10.10	4.30	38
	620		10.10	4.63	12

Glass Type	Index of Refraction n_D	Dispersion U ν_D	Dimensions Diameter inches	Dimensions Thickness inches	No. Pieces
DBC-1	611 SK Series	588	7 9/16	5/8	1
Dense Barium Crown (SK-3-4)			7 15/16	5/8	1
			8.0	5/8	1
			8.0	11/16	3
			8.0	3/4	2
			8.0	13/16	1
			8.5	1.0	1
			8.0	1 1/8	1
			8 1/16	1 1/16	2
		572	8 1/8	3/4	1
			9.5	13/16	1
		588	9 3/4	13/16	1
			9 15/16	5/8	1
			9 7/8	1.0	3
			10.0	1.5	1
			11 3/8	1 1/8	13
			11.98	.095	40
			12.54	2.61	13
DBC-2	617	550	8.0	3/4	6
			8.0	1 1/16	3
			9 7/8	1 3/4	1
			9 15/16	3/4	1
			9 15/16	1 3/8	1
			9 15/16	1 11/16	1
			10.0	15/16	3
			10.0	1 15/16	1
			11 1/8	1 5/8	1
			11.0	1 11/16	2
			13.5	1.0	1
			16 1/8	1 1/16	2

Glass Type	Index of Refraction n_D	Dispersion U	Dimensions Diameter inches	Thickness inches	No. Pieces
DBC-3	611	572	6.0	1.0	1
			6.5	7/8	2
			7.25	1.0	1
			9.0	3/4	1
			9.25	3/4	3
			9.25	7/8	3
			9.25	1 1/16	2
			9 5/16	7/8	2
			9 5/16	1.0	2
			9 5/16	1 1/16	4
			9.5	3/4	1
			9.5	7/8	8
			9.5	1.0	6
			9 9/16	11/16	3
			9 5/8	7/8	1
			9 3/4	5/8	1
			9 3/4	3/4	1
			9 3/4	11/16	1
			9 13/16	3/4	3
			9 3/4	1.25	5
			9 15/16	2 1/8	1
			9 3/4	1.0	2
			10.0	7/8	10
			10.0	1 1/16	3
			10.0	1 1/8	1
			10 1/16	7/8	11
			10.0	2 5/16	1
			10 1/16	1 1/16	2
			10.25	7/8	1
			10.25	1 1/16	2
			10.25	3.0	11
			10 5/16	3/4	1
			10 3/8	3.25	2
			10.5	3/4	11
			10.5	7/8	1
			10.5	1.0	2

lass ype	Index of Refraction n_D	Dispersion ν	Dimensions: Diameter inches	Dimensions: Thickness inches	No. Pieces
DBC-3	611	572	10.5	1 1/8	1
			10.5	1.25	1
			10.5	2 5/8	1
			10.5	3.0	5
			10.5	3.5	4
			10 5/8	3.0	1
			10 9/16	13/16	3
			10 9/16	7/8	1
			10 3/4	3 1/8	1
			10 13/16	3/4	~~2~~ 0
			11.0	3/4	5
			11.0	7/8	1
			11.0	1.0	1
			11.0	2.0	1
			11.25	1 1/8	1
			11 5/8	7/8	1
			11 3/4 x 11.5	3.0	1
			11 7/8 x 11 7/8	2 5/8	1
			11 5/8 x 11 3/4	2 3/4	1
			11 9/16 x 11 3/4	2 3/4	6
			11 3/4 x 11 3/4	2 7/8	1
			11 3/4 x 11 3/4	3 3/4	1
			12.0	7/8	1
			12.0 x 12.0	2 3/4	1
			12.5	7/8	1
			13 3/8	1 9/16	1
			13.5 x 13 1/8	3 1/8	1
			13.5	1 15/16	1
			13.5 x 13.5	3.0	1
			13 3/4 x 14.0	2 5/8	1
			15 7/16	1 9/16	1
			10.25	1 1/8	3
			15.5	3 1/16	1
			15.5	2 5/16	4
			16.0	2.25	2

GLASS TYPE	Index of Refraction n_D	Dispersion U	Dimensions Diameter inches	Thickness inches	No. Pieces
DBC-3	611	572	16.0	2 7/8	4
			16.25	3 3/16	1
			18.0	2.25	1
			18.0	3.0	5
			18 3/8	2 13/16	1
			18.5	2 13/16	1
			18.5	3 5/8	1
			18 5/8	2 7/8	1
			18 5/8	3.25	1
			18 3/4	2 3/4	1
			18 9/16	3.25	1
			18 13/16	3 3/16	1
			18 15/16	2 7/8	1
			19 1/16	2 15/16	1
			19 7/8	3 1/8	1
			20.0	2 1/8	3
			20.25	3 7/8	1
			21 3/8	2 7/8	1
			22.25	2.0	1
DBC-5	639	556	9.0	2.0	1
			12.5 x 10 9/16	2 3/4	1
DF-1	605	380	10.5	2 3/8	30
			10.6	1.19	1
			11 1/8	2 3/8	5
			11.2	3.85	32
			11.68	4.3	52
			11.97	2.2	24
DF-2	617	366	7 3/4	2.0	26
			7 7/8	2.0	21
			8.0	2.0	85
			8.0	2.5	78
			8.0	2 5/16	12
			8.0	2 9/16	3
			12.0	6.0	5
			12 3/4	4.5	1

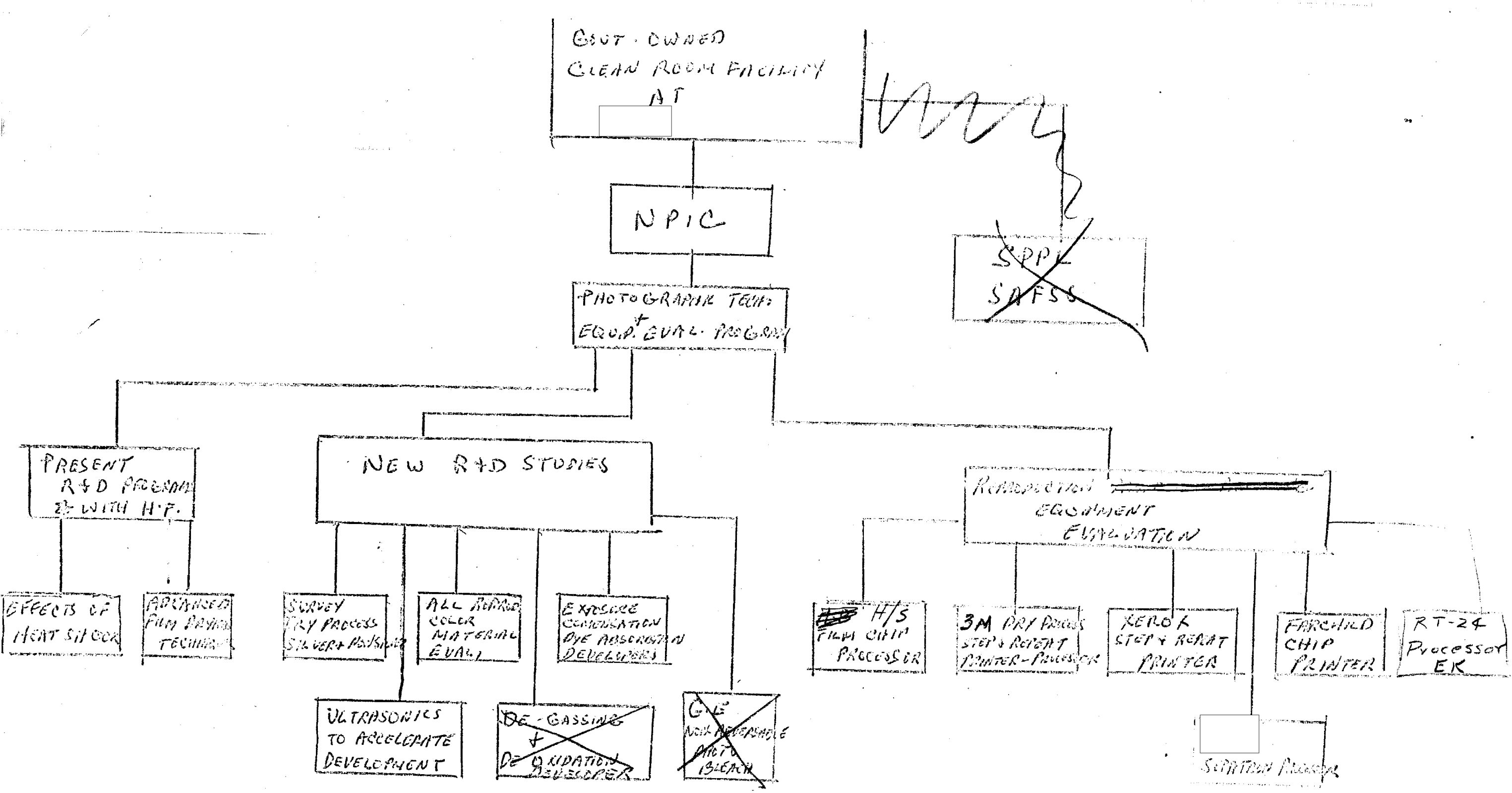
Glass Type	Index of Refraction n_D	Dispersion U	Dimensions: Diameter inches	Dimensions: Thickness inches	No. Pieces
DF-2	617	366	12 7/8	4 3/8	1
			13.0	4.5	5
			19 1/8	1 7/8	1
DF-4	649	339	7 13/16	1.0	1
			8.0	1.5	1
			9 3/4	1 5/8	1
			9 7/8	1 9/16	2
			10.0	1 15/16	1
			12.25	1 3/4	1
			14.25	1.25	1
			15 1/8	1.5	1
			15 7/8	1 5/8	1
			16 3/8	15/16	1
			16 3/16	1 11/16	1
			16.25	1.0	1
EDF-3	720	293	13.35	2.7	16
F-2 Flint	620	363	6 7/8	1 5/8	1
			9.4	2.2	13
			14.0	3.2	3
F-4 Flint	617	366	7.85	2.0	13
			8.35	1.5	4
			10.8	5.6	11
			11.65	3.8	12
F-8 Flint	596	392	6.2	1.9	40
			6.6	1.6	40
			8.35	1.5	2
			24.2	3.54	1
			24.4	3.66	1
			24.25	3.25	1
			24.8	3.9	2

Glass Type	Index of Refraction n_D	Dispersion U	Dimensions: Diameter inches	Dimensions: Thickness inches	No. Pieces
F-15 Flint	606	370	11.7	3.9	15
			11.7	4.4	8
			12.7	2.1	13
K-5 Crown	523	591	8.35	1.5	2
			9.0	2.0	2
			9.4	2.0	2
			12.0	2.5	2
K-7 Crown	511	606	9.0	2.0	2
			12.0	2.5	2
KF-3 Crown Flint	515	547	6.0	1.5	2
			8.35	1.5	2
			9.0	2.0	2
			9.4	2.0	2
			12.0	2.5	2
KF-4 Crown Flint	534	516	13.75	2.3	13
			8.35	1.5	2
			14.75	2.35	13
			19.5	3.2	4
			20.5	3.1	4
KZFS-1 Dense antimony flint	614	444	8.35	1.5	2
KZF-4 Antimony Flint	570	481	6.3	1.5	2
			8.35	1.5	2
KZF-5 Antimony Flint	521	528	6.3	1.5	1
			8.35	1.5	2
KZF-6 "	527	511	6.3	1.5	4
			8.35	1.5	2
LAK-3 Lanthanum Crown	694	535	6.3	1.5	2
			10.0	2 3/4	3

Glass Type	Index of Refraction n_D	Dispersion U	Dimensions: Diameter inches	Dimensions: Thickness inches	No. Pieces
LF-1 Light Flint	573	427	6.0	1.5	1
			9.0	2.0	2
			12.0	2.5	2
LF-4 "	549	457	8.5	15/16	1
LF-5 "	582	408	6.0	1.5	2
	549	457	8.5	1.0	3
			8.5	1.25	1
	582	408	6.0	1.5	2
	549	457	8 31/32	1 11/16	1
	582	408	8.35	1.5	2
			9.0	2.0	2
			12.0	2.5	2
LLF-1 Xtra Light Flint	548	459	8.35	1.5	2
SF Dense Flint	750	278	21.65	3.0	16
SF-4 "	755	275	8.35	1.5	2
SF-8 "	689	311	8.35	1.5	2
SF-18 "	722	293	8.35	1.5	2
SK-1 Dense Barium Crown	610	565	13.75	2.45	15
			14.75	2.25	11
			19.5	3.1	4
			20.5	3.5	4
SK-4 "	613	586	5.2	1.5	40
			8.35	1.5	3
			9.4	2.0	2
			10.2	4.5	13
			11.5	2.0	12
			12.5	2.5	26
SK-5 "	613	586	11.5	2.0	1

Glass Type	Index of Refraction n_D	Dispersion U	Dimensions Diameter inches	Thickness inches	No. Pieces
SK-10	623	572	6.0	1.5	2
			9.0	2.0	2
"			12.0	2.5	2
SK-15	623	582	23.4	3.38	1
			24.0	2.87	2
"			24.2	3.54	1
			28.75	3.78	1
SK-16	620	603	6.3	1.5	2
			8.35	1.5	2
			10.0	4.4	6
"			10.2	4.8	12
SK-19	613	573	10.5	2.5	2
			11.3	2.0	40
"			12.5	3.0	2
SSK-1 Extra Dense Crown	617	540	9.4	2.0	2
			8.35	1.5	2
SSK-4 "	618	551	8.35	1.5	3
SSK-5	658	508	6.0	1.5	2
"			9.0	2.0	2
			12.0	2.5	2

Glass Type		Index of Refraction	Dispersion	Dimensions		No. Pieces
				Diameter Inches	Thickness Inches	
Grade	A	523	584	19 1/2" x 19 1/2"	1 1/4"	~~11~~ 7
	B			19 1/2" x 19 1/2"	1 1/4"	8
	C			19 1/2" x 19 1/2"	1 1/4"	44
	D			19 1/2" x 19 1/2"	1 1/4"	77
Grade	A	523	584	12 1/2" x 11 3/4"	3/4"	118
	B			12 1/2" x 11 3/4"	3/4"	69
	C			12 1/2" x 11 3/4"	3/4"	173
	D			12 1/2" x 11 3/4"	3/4"	236
Grade	A	523	584	16" x 12 1/8"	7/8"	6
	B			16" x 12 1/8"	7/8"	5
	C			16" x 12 1/8"	7/8"	27
	D			16" x 12 1/8"	7/8"	39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RT-24 Processor EK
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25X1

25X1